Scientific Report No. EIR-822

AFCRL-69-0286

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# DEVELOPMENT OF A LOW LEVEL SOUNDING SYSTEM

by

Raymond G. Ramirez
Robert J. Betz, James R. Cosby

The Bendix Corporation
Environmental Science Division
1400 Taylor Avenue
Baltimore, Maryland 21204

Contract No. AF19(628)-5117

Project No. 6682
Task No. 668201
Work Unit No. N/A

FINAL REPORT

Period Covered: February, 1966 through July, 1968

May, 1969



Contract Monitor: Gordon J. Canning, Jr., Capt., USAF
Aerospace Instrumentation Laboratory



Prepared for

Air Force Cambridge Research Laboratories
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# ABSTRACT

The results of a program to develop, design and fabricate a low-level telemetry subsystem to operate in the lower 1,000 meters of the atmosphere and compatibly interface with a modified Rawin Set AN/GMD-4 is presented herein. The subsystem has been designed to provide a detailed analysis of the temperature, humidity and wind structure of the lower atmosphere, employing standard radiosonde sensors and transponder techniques, and consideration has been given for the use of modular construction to facilitate updating as new techniques and equipments are developed. The telemetry device is adaptable for use as a balloonsonde designed for data acquisition on ascent, or as a rocketsonde providing data acquisition on descent, upon deployment of a parachute and a sensor mounting package.

Utilized in the design of this telemetry device are: a solid state and integrated circuit commutator, with a sampling rate of one cycle per second, and a solid state microwave transmitter. The relatively high sampling rate of one every second provides a more complete synopsis of the atmospheric construction than have previous balloon borne or rocket sounding telemetry devices.

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## INTRODUCTION

This report includes the development of a low level radiosonde instrument package containing solid state devices consistent with the state-of-the-art technology. Also included is the detailed design approach used in the development of a modification package for the AN/GMD-4 Meteorological Data Processor to make the GMD subsystem operation compatible with the low level radiosonde data sampling and transmission rate.

This report covers the step by step procedure and the analysis of each circuit implemented in the design, includes a detailed description of the various qualifying tests at the circuit and completed unit levels and discusses the results of USAF/Bendix flight tests conducted at Cape Kennedy in June and October of 1967, at L. G. Hanscom Field in April of 1968, and at Vandenberg AFB in June of 1968.

## SCIENTIFIC CONTRIBUTORS

Those scientists and engineers who have contributed and their areas of contribution to the research reported on in this document are discussed below:

1. R. G. Ramirez - Engineer

   Mr. Ramirez was responsible for reviewing the original design, researching the problem areas and initiating corrective action, building of the prototype units, flight testing these units at Cape Kennedy, employing any necessary redesign resulting from flight testing and the writing and assembling of the necessary data incorporated in this report.

2. R. J. Betz - Engineer

   Mr. Betz performed the circuit design and assembled the AN/GMD-4 modification package, had the responsibility for implementing the modification to the GMD-4 at Cape Kennedy and at L. G. Hanscom Field. Mr. Betz also assisted in the design and analysis of the solid state commutator switching device, and contributed to the write up of this report.

3. J. R. Cosby - Engineer

   Mr. Cosby was the Program Manager on this development program, with the responsibility for defining and implementing the original design concept. He provided considerable technical assistance in the basic design of the hybrid unit throughout the program.

4. K. Kidd - Engineer

   Mr. Kidd as the Project Engineer performed much of the basic research required on this program. He provided technical direction to his subordinate engineers and technicians throughout the development and testing phases on the breadboard units up to the in-house Bendix prototype manufacturing and testing phase.

5. F. H. Stein - Engineer

   Mr. Stein contributed to the design of the receiver, the receiving antenna, the low frequency clock, the solid state commutator and the blocking oscillator. He participated in the breadboard build up and testing phases implementing his design.

6. R. Erler - Engineer

Mr. Erler performed much of the basic design of the receiver, the 82 KC amplifier design and assisted in the design of the low frequency clock and the solid state commutator. He also participated in the breadboarding and testing of these circuits.

# TECHNICAL

## A. GENERAL

The transponder portion of the radiosonde consists of the 403 MHz receiver, 2 stages of 81.94 KC amplification, an emitter follower isolation stage, and a 1.68 GHz solid state transmitter. The receiver demodulates the 81.94 KC ranging signal, provides the driving voltage to the 81.94 KC amplifiers, the amplifiers drive into a Hi-input impedance emitter follower whose output frequency modulates the 1.68 GHz solid state transmitter, thus retransmitting the ranging signal back to the GMD ground station.

The meteorological data is sampled at the rate of once per second, and is transmitted by pulse modulating (FM) the 1.68 GHz transmitter with pulse rates ranging from 200 to 4,000 cycles per second.

Meteorological data commutation is provided by a four (4) channel solid state commutator. The solid state commutator consists of a four (4) Hertz clock (astable multivibrator), a sequencer (provides gating) and appropriate switching transistors. Each data channel pulse modulates the transmitter for a time period of 230 milliseconds with a 20 millisecond blanking time period (off time) provided between data channels. Sequence identification for the commutator is reference, temperature, humidity, and spare channel.

## B. BATTERY POWER

Power requirements of the transmitter, receiver, transistor circuits, micrologic circuits and the meteorological pulse generator, commutator and blocking oscillator circuits dictated the size and voltage of the batteries that were required. The RCA solid state transmitter (S-190) requires a -18 V @ approximately 100 ma supply, the 403 MHz receiver and associated 81.94 KC transistor circuitry was designed to operate at -12 V while the met pulse generator, and the micrologic and associated audio transistor circuitry was designed to operate at -4.5 Volts. Total current drains at each voltage are, -18V @ 100 ma max., -12 V @ 15 ma max., and -4.5 V @ 100 ma max.

Consideration was given to several types of batteries and the field was narrowed down to the size AA alkaline cells and the cuprous-chloride water-activated battery. Both batteries were capable of supplying at least 250 ma over a thirty minute period.

The alkaline batteries, after additional testing were found to provide no margin of safety. The time required to baseline and launch a balloonsonde is approximately 20 minutes, and for the rocketsonde about 30 minutes; therefore, the use of the alkaline battery was abandoned.

The cuprous-chloride water-activated battery manufactured by the Ray-O-Vac Corporation was selected. This unit will supply full power approximately ten minutes after being soaked in fresh water for two to three minutes. The manufacturer specified this unit's capability as 250 ma for approximately sixty minutes. Under test, at the Bendix facility, and during flight tests at Cape Kennedy, the unit was found to exceed this power capability. During flight testing at the Cape, one radiosonde (balloon) was released and met data and ranging information were received for about three hours before fading. Under bench test conditions a battery was activated and allowed to lay for seven hours; the batteries were then put in a sonde under full load, voltage measurements were made and found to still be at their nominal values. From these tests the cuprous-chloride batteries were found to provide at least a 300 to 400 percent safety margin. The weight of the battery is approximately 61 grams activated. The only hardware necessary for connecting this battery is the standard widely used two-terminal snap-on type. This was an additional weight saving factor. In addition to the foregoing, the cuprous-chloride cost per cell was about 20% less than that for the alkaline cell.

See Figures 1 and 2 for a comparison of battery voltage measurement made under full load during laboratory tests.

## C. MECHANICAL DESIGN

### 1. Rocketsonde

The packaging of the instrument was made to specifically fit into the Texaco "Cricket Rocket" which has a modified ejection type nose section. All electronic subassemblies of the instrument except the transmitter are on printed circuit boards. The weight of the electronic package including the activated battery is 645 grams (approximately 1.42 pounds). The electronic package consists of the 1.68 GHz transmitter, the 403 MHz receiver, the 81.94 KHz amplifiers, the power source, the solid state commutator, the met data pulse generator and the associated frame and mounting hardware. Refer to Figure 3 for picture of instrument at various stages during the assembly process.

The electronics package fits into the Texaco "Cricket Rocket," and makes up the nose or payload package. The parachute compartment attaches to the rear of the payload and houses both the parachute, the 15 second timer and the rocketsonde sensor package. The 15 second timer deploys the parachute approximately 15 seconds after firing of the rocket motor. This is the calculated time for the rocket after firing to reach apogee at which time zero G forces are encountered. The parachute is attached just aft of center of the whole assembly and provides a descent of the package with a

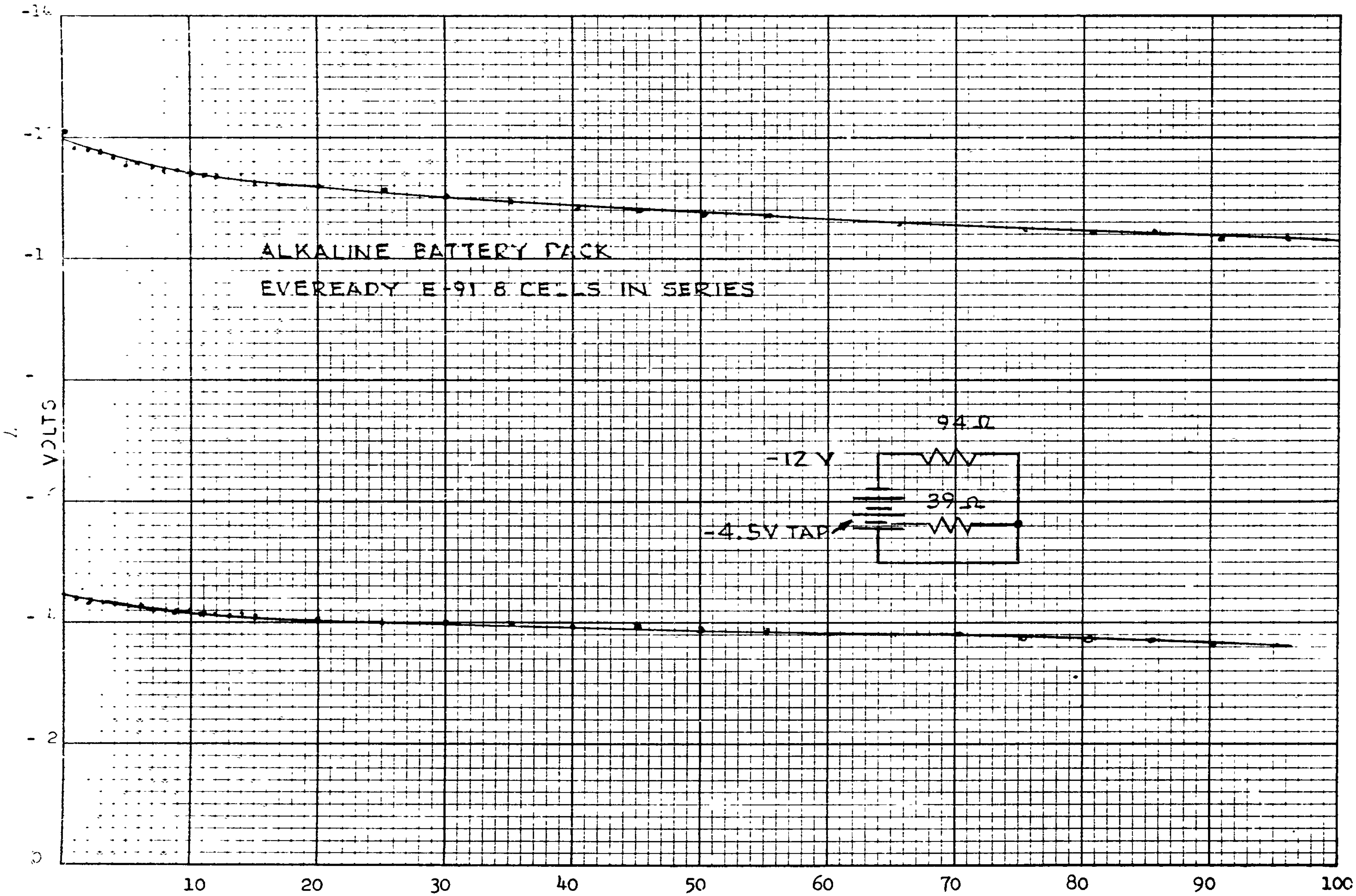

ALKALINE BATTERY PACK
EVEREADY E-91 8 CELLS IN SERIES
94 Ω
39 Ω
-12 V
-4.5V TAP
VOLTS
-1
- 2
10
20
30
40
50
60
70
80
90
100
TIME (MINUTES)

Figure 1

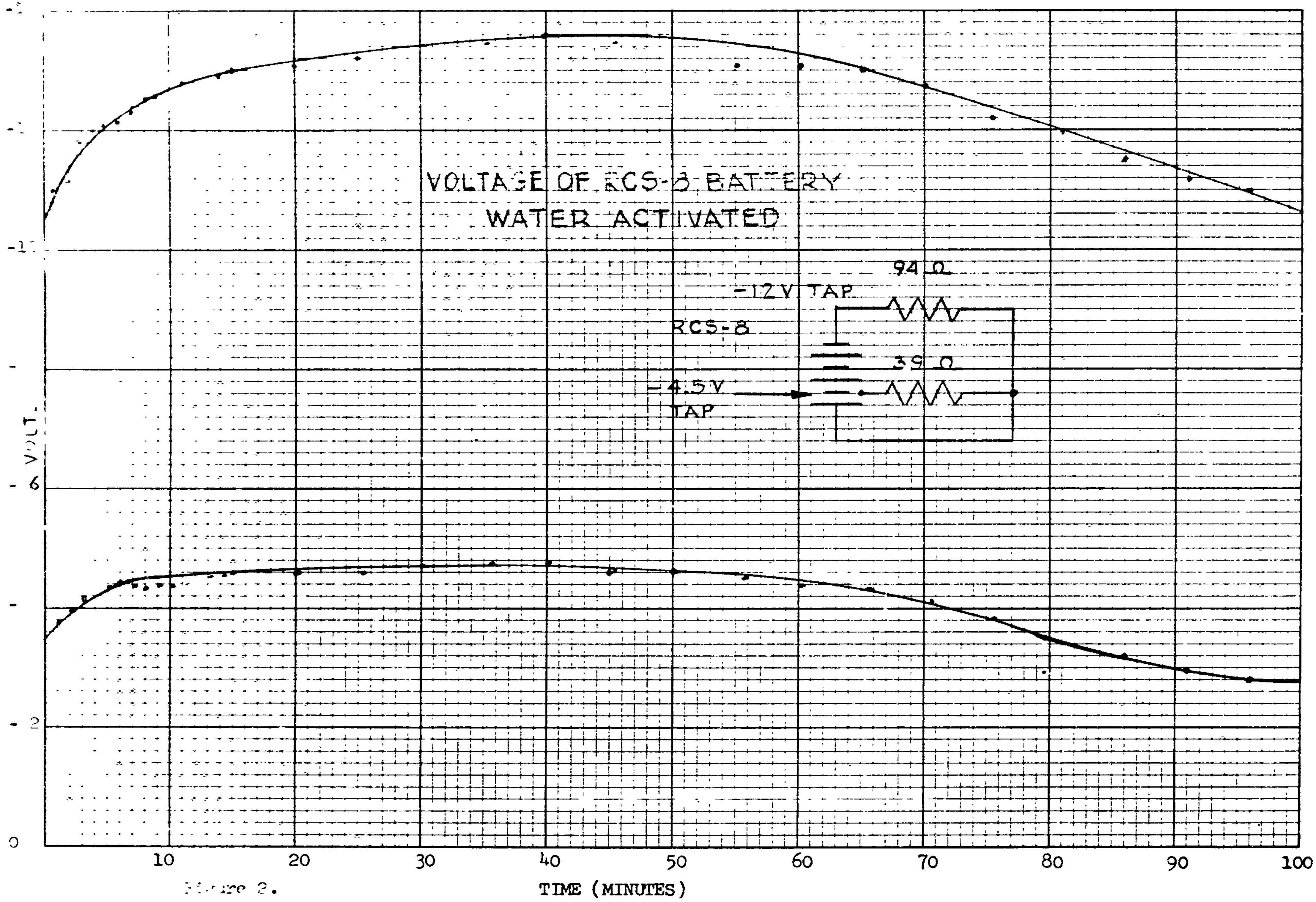

VOLTAGE OF RCS-8 BATTERY
WATER ACTIVATED
94 Ω
-12V TAP
RCS-8
39 Ω
-4.5V
TAP
VOLT.
-10
-6
-2
0
10
20
30
40
50
60
70
80
90
100
TIME (MINUTES)

Figure 2.

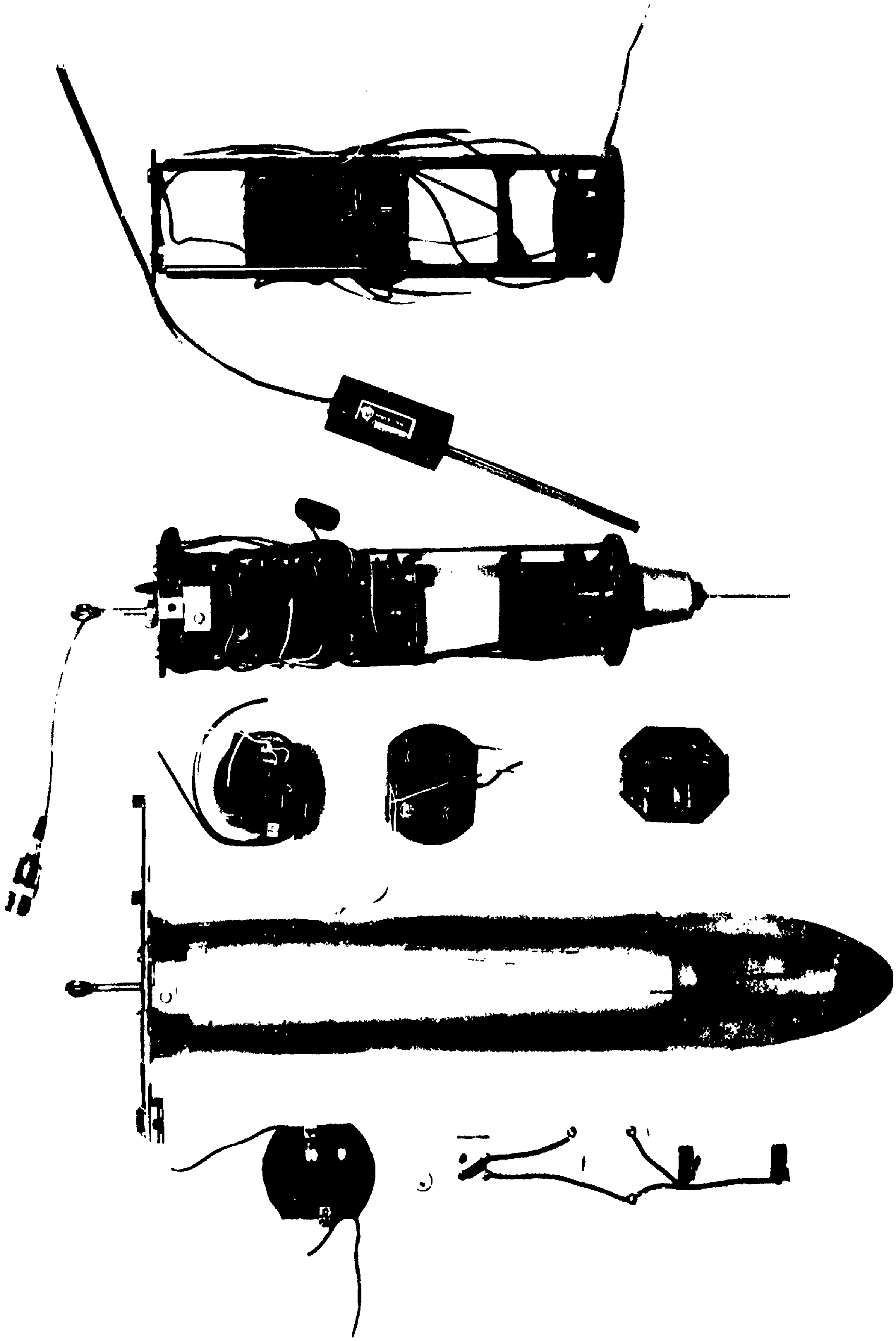


Figure 3

nose down attitude. This eliminates any transmission dead space that would occur if the assembly descented in a nose up attitude whereby the metallic case of the rocket motor would block transmission of the instrument as it revolved between the instrument and the ground receiving station during descent. The nose down attitude angle is approximately 35° below the horizontal.

The outer housing of the instrument package is aluminum and attaches to the instrument package with two (2) machine screws. The payload assembly attaches to the parachute assembly by use of three (3) machine screws fastened to the payload assembly which fit into three (3) slots in the parachute assembly frame, are turned and then tightened. This provides a rigid attachment of the payload to the "Cricket Rocket."

The electronic package is comprised of five (5) printed circuit boards which includes the encased receiver board, which are all equally spaced and each, excluding the receiver subassembly, is fastened to the lightweight aluminum frame by use of two (2) aluminum angle brackets. The receiver board is mounted in a metal shield which is fastened to the aluminum frame with two metal screws. This construction lends itself to a self supporting rigid package sufficient to withstand 84 g's of shock, that is encountered during launch.

The ejection type nose cone originally proposed was found to be inadequate for the purpose intended. Great difficulty was encountered in attaining the necessary rigid fit of the nose cone to the payload assembly needed during descent and then at apogee to have the nose cone jerk loose from the instrument as a result of parachute deployment and gravitational forces. Flight tests conducted by AFCRL at Cape Kennedy showed that another approach was necessary. In addition to the above concept, the sensor board provided had foldable arms. The sensor board plugged into the instrument by use of banana plugs and then folded up to allow installation of the nose cone. At apogee the nose cone was to drop off and the sensor arms were then to deploy. This configuration was changed, and the nose cone was redesigned to lock onto the instrument. With this change in the configuration, it was then required to move the sensor package from the nose cone to the parachute assembly. A new sensor package was designed and during ascent the sensor package was installed into the parachute assembly and fastened to the parachute lanyard. The sensor package was still deployed at apogee. This allowed the sensor package to remain clear of the instrument such as internally generated heat and reflections caused by the rocket assembly. This new concept of securely fastening the nose cone to the instrument during the whole

flight protects the RF transmitter antenna upon impact with the surface, and the use of the low loss plastic material for the nose cone enables the RF transmission to be made through this material.

The center of gravity of the electronic instrument package will be slightly forward of center. This will allow the Cricket Rocket performance to be comparable to other versions of the Cricket Rocket with meteorological payloads.

2. Balloonsonde

The electronic package for the balloonsonde is the same as for the cricketsonde with the exception of the location of the sensor unit.

In the original design, a metal tube was used as the cover for the balloonsonde, as well as for the rocket version. In order to make a cost reduction to the unit, the metal case was abandoned. An aluminum foil wrapped cardboard tube provided a sufficiently tight fit, so that no other means of fastening was necessary. The cardboard tube was much easier to use than the metal container. It enabled the batteries to be inserted, the clock timer to be set with ease, by slipping off the tube, whereas the metal case was secured by two (2) metal screws.

Good sensor position is achieved on the balloonsonde by plugging the sensor board at the end of the instrument package opposite the 1.68 GHz transmitter. The banana plug in feature is also provided here. In this position the sensors will sample clean air during ascent. For shipping purposes, the sensor arms are folded in a disposable cardboard end cap which is attached with two (2) tie wraps.

D. ELECTRONIC INSTRUMENT PACKAGE DESIGN

1. 403 MHz Receiver and 81.94 KHz Amplifiers

The receiver developed for the Low Level Radiosonde was determined from the results of the following calculations and tests.

a. A mathematical analysis to determine the required receiver sensitivity:

The radiosonde instrument package is designed to sense atmospheric parameters up to an altitude of 1,000 meters with an ascent or descent rate of 150 meters per minute. Therefore, the time of ascent or descent will be approximately six minutes. A maximum wind speed of 50 miles per hour is selected

for design purposes. Then the maximum slant range is approximately five miles.

The path loss for a 5 mile transmission at 400 MHz =

| | | | |
|---|---|---|---|
| $37 + 20 \log (400) + 20 \log (5)$ | = | 103 | db |
| Fade Margin | = | 3 | db |
| Sonde Receiver Antenna Gain | = | 0 | db |
| Sonde Receiver Noise Figure = Assume | | 5 | db |
| GMD Transmitter Power = 18 watts | = | 42.6 | dbm |
| GMD Transmitter 400 MHz Antenna Gain | = | 15 | db |

The required receiver sensitivity =

Transmitter Power + Antenna Gain - Path Loss - Fade Margin - Noise Figure = 42.6 + 15 - 103 - 3 - 5 = -53.4 dbm.

For design purposes the antenna was assumed to be 50% efficient. Therefore, the design sensitivity is -56.4 dbm.

b. A mathematical analysis of various receiver configurations:

Three different types of receivers were considered: A self-quenched superregenerative detector, an RF amplifier followed by a diode detector, and an RF amplifier followed by a transsistor detector.

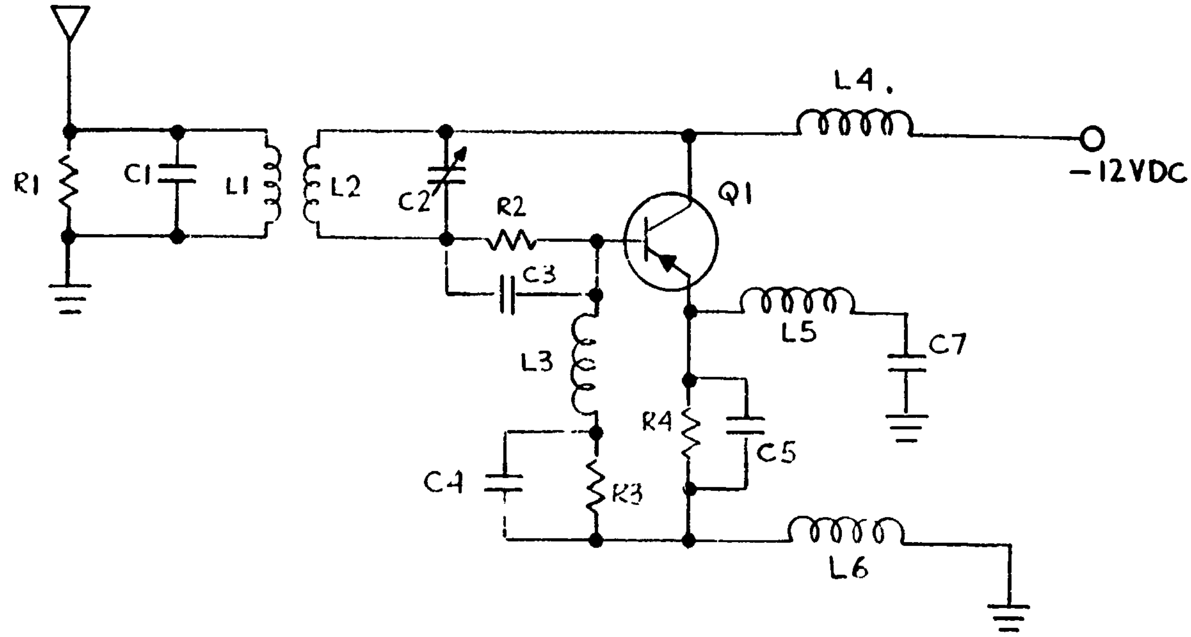



Figure 4. Superregenerative Detector

The superregenerative detector, illustrated in Figure 4 above was analyzed. From past experience with this circuit, it is known that a sensitivity of -72 dbm for a 10:1 detected signal-to-noise ratio can be realized. The detected signal has an amplitude of 15 mv peak-to-peak. This value is relatively constant over a wide range of RF signal strength due to the inherent automatic gain control of a logarithmic mode super-regenerative detector.

The RCA S190 sol d state power source requires approximately 300 mv peak-to-peak for ± 100 kHz frequency deviation. The superregenerative detector should be followed by one or two amplifier stages and an emitter follower to produce the required modulation voltage and isolation.

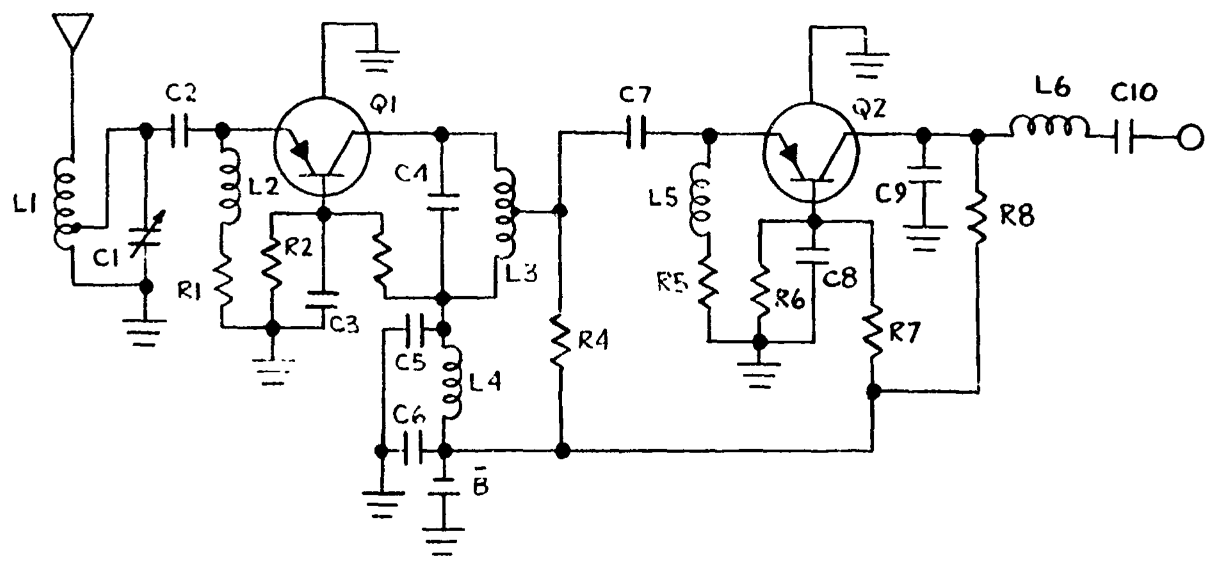



Figure 5. RF Amplifier and Transistor Detector

The transistor RF amplifier and transistor detector, illustrated in Figure 5 were analyzed next. The maximum gain of an RF amplifier using inexpensive RF transistors was calculated to be 13 db with a noise figure of 6 to 7 db. The input to the detector would then be -56.4 dbm + 13 db = -43.4 dbm.

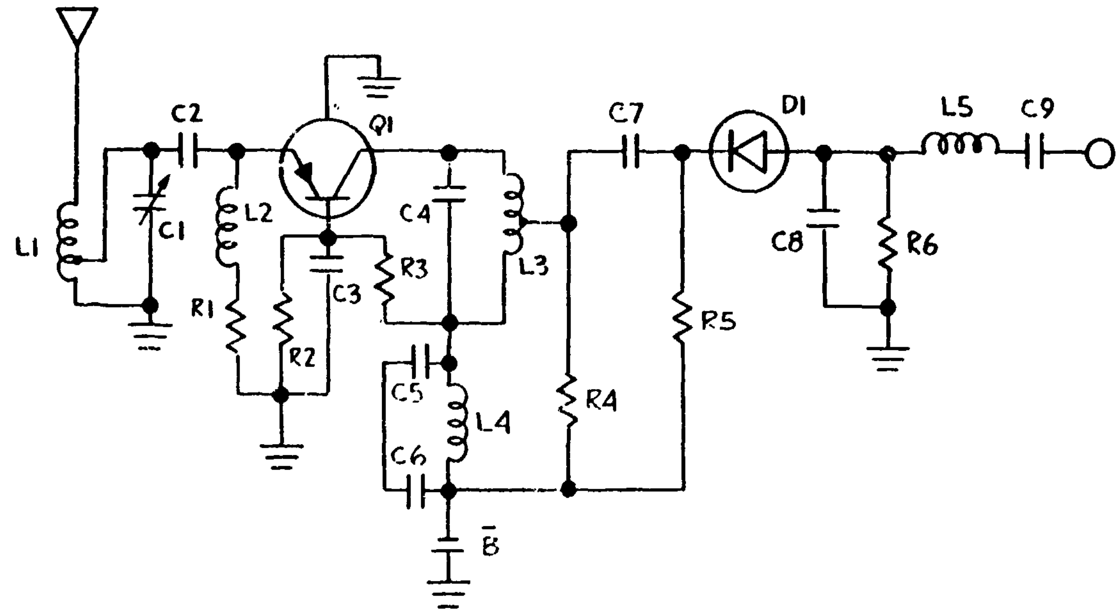



Figure 6. RF Amplifier and Diode Detector

The RF amplifier and diode detector, illustrated in Figure 6 were analyzed next. From the previous calculation, the input to the detector would be -43.4 dbm. If the diode is assumed lossless, then the output is -43.4 dbm = $4.571 \times 10^{-5}$ mw.

c. Breadboard Testing

Because there was much information on the performance of the superregenerative detector and because the transistor detector had more gain than the diode, the first breadboard built was a transistor detector employing a 2N2996 transistor.

After optimizing the first circuit, a sensitivity of about -48 dbm was obtained. Other 2N2996 transistors were tried in the circuit and sensitivities of -1 to -6 dbm were obtained. An optimum circuit for the majority of the 2N2996 transistors (sample lot of 10) was developed and sensitivity ranged from -42 dbm to -15 dbm with the majority around -28 db. Since the output from the RF amplifier stage would be -43.4 dbm, the transistor detector was rejected. The amplitude of the detected signal was approximately 2 mv peak-to-peak.

The superregenerative detector shown in Figure 4 was built next. (See Superregenerative Receivers, Modern Radio Technique Series, by J. R. Whitehead, The Cambridge University Press, American Branch, New York, for explanation of the operation of a superregenerative detector.)

Breadboard operation of a high frequency receiver is difficult because component lead lengths are critical. Any leads that are connected to the inductance loops become part of the input circuit and cause frequency shifts. Stray capacitance is detrimental to high frequency performance, so printed circuit boards were fabricated to reduce this stray capacitance to a minimum. The use of printed circuit boards also provides control over component placement which can also offset high frequency operation. In addition, the receiver was shielded to minimize interference from the 1.68 gHz transmitter.

Test results of the superregenerative detector using a Texas Instrument 2N2996 transistor showed a sensitivity of -79 dbm when tuned to 403 MHz. With the receiver tuned to 403 MHz, the input frequency from a signal generator was shifted to 395 MHz and the sensitivity measured again. This time the sensitivity was approximately -9 dbm or 70 db less.

Because of the results obtained with the transistor detector, no diode detector was built since any RF amplifier-detector combination would cost more than the superregenerative detector.

The 81.94 kHz amplifier is used in the radiosonde to provide signal amplification and impedance matching with the transmitter. Refer to Figure 7 for a description of the circuit.

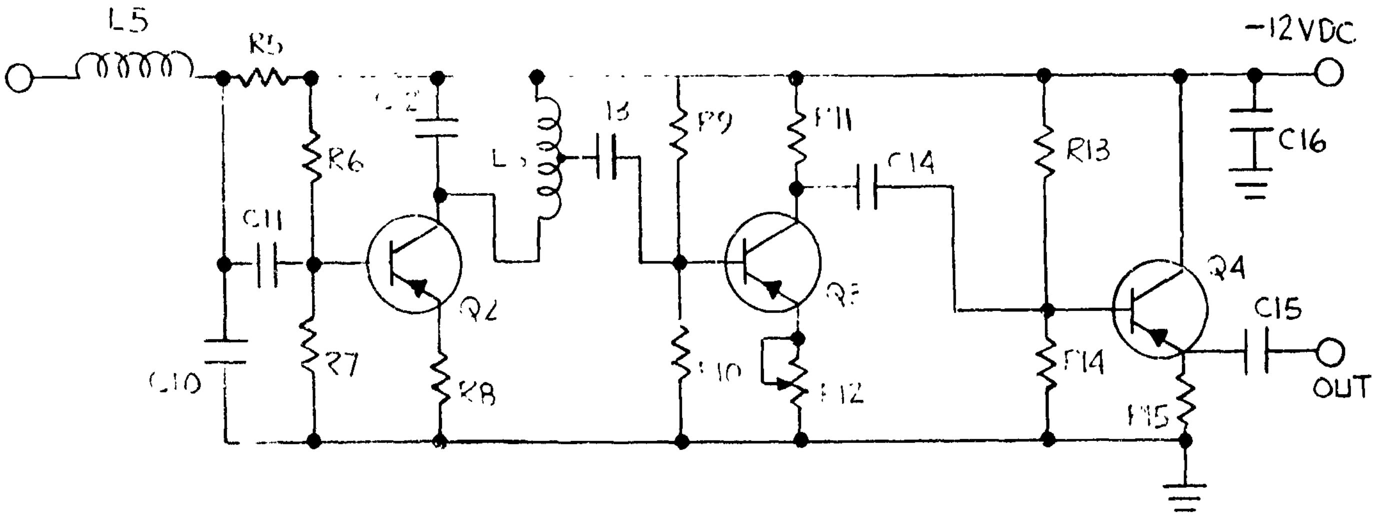



Figure 7. 81.94 KHz Amplifier

The tank composed of C12 and L6 is tuned to resonate at 81.94 KHz. This allows a voltage gain of approximately 15 for signal frequencies and little or no gain for other frequencies. A second stage provides additional voltage gain with gain control R12 used to provide the proper level. An emitter follower is used to provide an impedance match to the 600 ohm input of the transmitter.

2. Meteorological Data Pulse Generator

The Meteorological Data Pulse Generator FM modulates the 1.680 GHz transmitter from 200 to 4,000 pps. The frequency of the meteorological pulses are controlled by the resistance of temperature and humidity sensors switched into the circuit by means of the solid state commutator, which is described in the next section. The four cycle per second solid state clock

provides the timing pulses for gating the temperature, humidity, high reference and spare channel resistances into the met data oscillator circuit. The pulse width supplied is not less than 20 microseconds in width as dictated by the response of the GMD receiver to narrow pulses in the range of repetition rates to be used in the sonde.

A resistance-controlled relaxation oscillation is needed to utilize the resistance variation property of the sensors. Frequency output of the oscillator is 4,000 pps with only the reference resistance in the circuit. Minimum frequency is near 200 pps with the sensors at maximum resistance.

A unijunction transistor is one device suitable for a relaxation oscillator because of its negative resistance characteristic. The low power supply voltage (12 volts) available dictated that a low voltage unijunction transistor such as the G.E. 5E35 be used. Refer to Figure 8 for operation of the unijunction circuit.

Emitter voltage of the unijunction (Q2) rises exponentially to its firing point. At this time the capacitor discharges through Q2 and its voltage drops to 0.2 volts. This voltage is coupled to the base of Q1 to provide a pulse output. Q1 also helps isolate the unijunction transistor from the load.

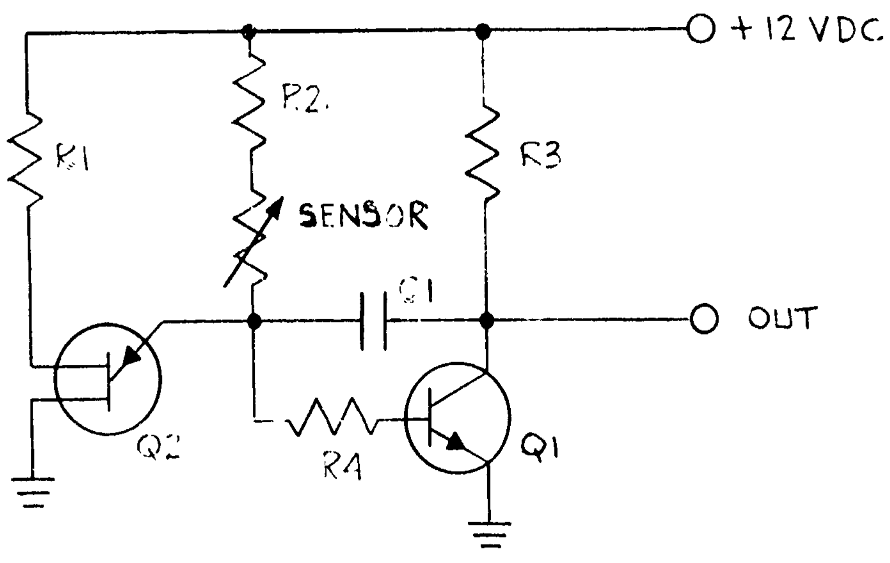



Figure 8. Unijunction Pulse Generator

Temperature stability of the circuit was quite poor; the output frequency varied from 3680 Hz at 15°C to 6585 Hz at -40°C.

Next, a Motorola four-layer diode (M41 3052) was used in a resistor-capacitor relaxation oscillator circuit. The four-layer diode acts similar to a neon bulb. It exhibits high resistance until breakdown then a low resistance while conducting. After the current through the diode decreases below the sustaining current, the device exhibits a high resistance again. Refer to Figure 9 for the circuit diagram.

No temperature check was made since the circuit was unstable at ambient temperature. Successive identical readings on a frequency counter could not be obtained due to pulse-to-pulse jitter. The output is a sawtooth which limits its usefulness unless a pulse shaper is used.

Refer to Figure 10 for a two-transistor saturated switching circuit using Motorola complementary transistors. When power is first applied to the circuit, Q1 saturates driving Q2 into saturation. The -4.5 volts appearing across R3 is coupled to the base of Q1 driving it further into saturation. The capacitor discharges until both transistors come out of saturation. At this time the voltage at the junction of R3 and the collector rises to zero volts. This voltage is coupled to the base of Q1. The capacitor then charges until Q1 again saturates and the process repeats itself.

Output frequency is controlled by the magnitude of the sensor resistor (R). When R equals 0 ohms frequency is 4,000 pps (reference frequency). Increasing R decreases the frequency to approximately 246 pps with R equal to 1.4 megohms.

Pulse width is controlled by C1 and R2. With the components shown, output pulse width is 25 microseconds. Decreasing R2 decreases the pulse width. The emitter follower isolates the met pulse generator from the 1.68 gHz transmitter.

Frequency varied from a low of 3990 pps at -10°C to 4026 pps at +70°C. This is better than ± 1% temperature stability over this temperature range.

The two-transistor saturated switching circuit was selected since it had the best temperature stability. This circuit is also more efficient than the other two since the pulse amplitude is almost equal to the power supply voltage in magnitude. Figure 13 shows the audio curve of this circuit.

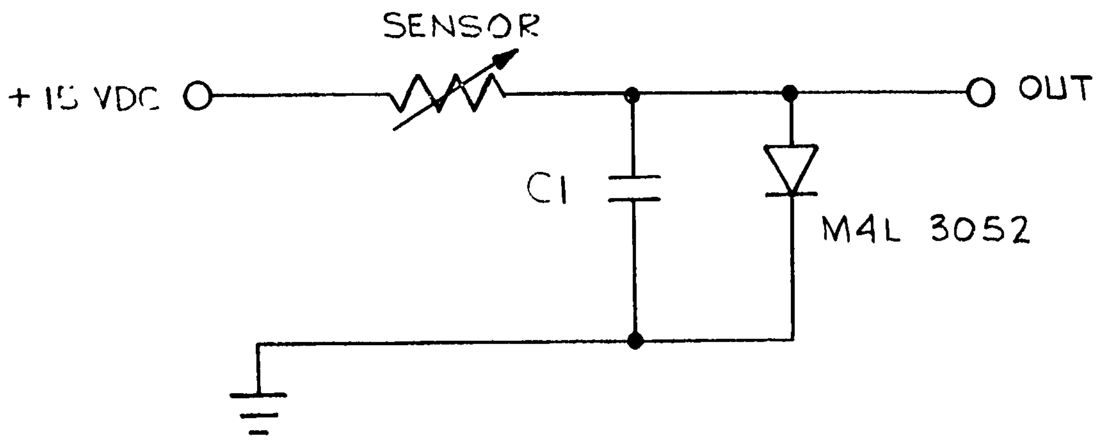



Figure 9. Four Layer Diode Pulse Generator

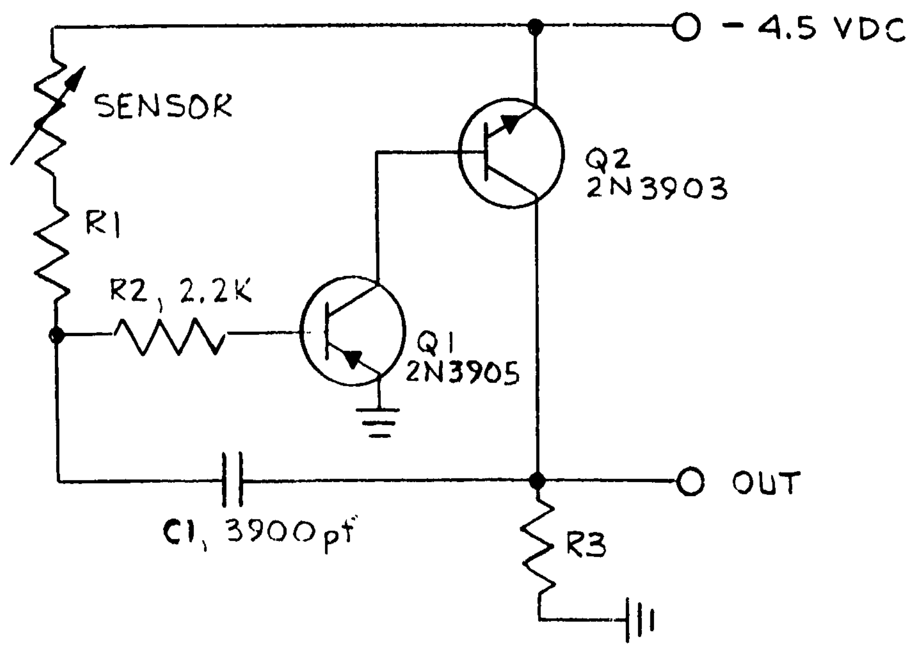



Figure 10. Complementary Transistor Pulse Generator

3. Solid State Commutator

A solid state commutator composed of a clock, sequencer, and switching transistors is used to gate the meteorological sensors in a resistance-controlled oscillator. To obtain the necessary sequence and duration for the sensors, a 4 Hz flip-flop is used to generate clock pulses. Each successive clock pulse switches the sensors and reference in the resistance-controlled oscillator circuit for the required time and in proper sequence.

a. Clock

Five different flip-flop circuits were tested in an effort to find a temperature and voltage stable clock circuit with low current drain.

The first circuit was composed of a Fairchild-type 914 micrologic dual 2-input gate with external feedback resistors and capacitors as shown in Figure 11. The 914 micrologic element is a digital device whose output is high (approximately zero volts) when the input is low (approximately -4.5 volts) and vice-versa. The inputs charge exponentially toward zero volts since they are connected to ground through resistor (R1 or R2). Since the output of element # 1 is connected to the input of element # 2 and output # 2 to input # 1 the unit will oscillate.

With all components in a temperature chamber, frequency varied from a low of 3.81 Hz at 50°C to 22.2 Hz at -10°C. The electrolytic capacitors were assumed to be unstable at low temperatures, so they were removed from the temperature chamber and attached to the micrologic circuit with long leads. Results of a retest showed a frequency variation of 5.11 Hz. While the capacitors affect the frequency to a large extent, the frequency shift due to the micrologic characteristics is still quite large.

A Fairchild-type 929 quad inverter was substituted for the dual 2-input gate as shown in Figure 12. The 929 inverter flip-flop circuit operates in the same manner as a 914 unit, but the 929 output has increased drive capability for charging the capacitors.

When the capacitors and resistors selected to produce 2 Hz at ambient temperature, frequency varied from 1.55 Hz to 70°C. to 2.76 Hz at -40°C. This was an improvement over the 914 element, but the percent change (35%) in frequency is still quite large.

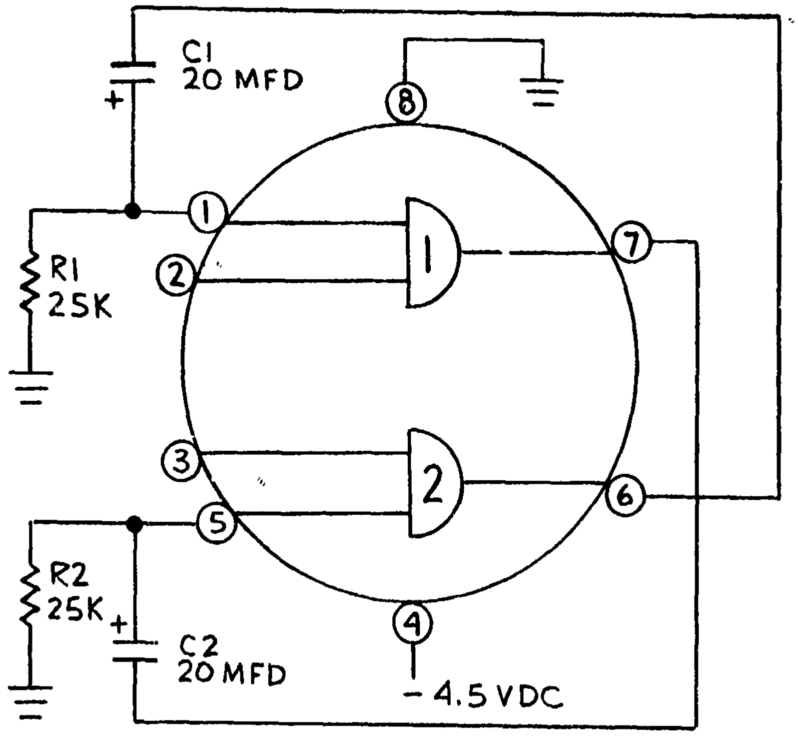



Figure 11. 4 Hz Micrologic Clock (Fairchild 914 Gate)

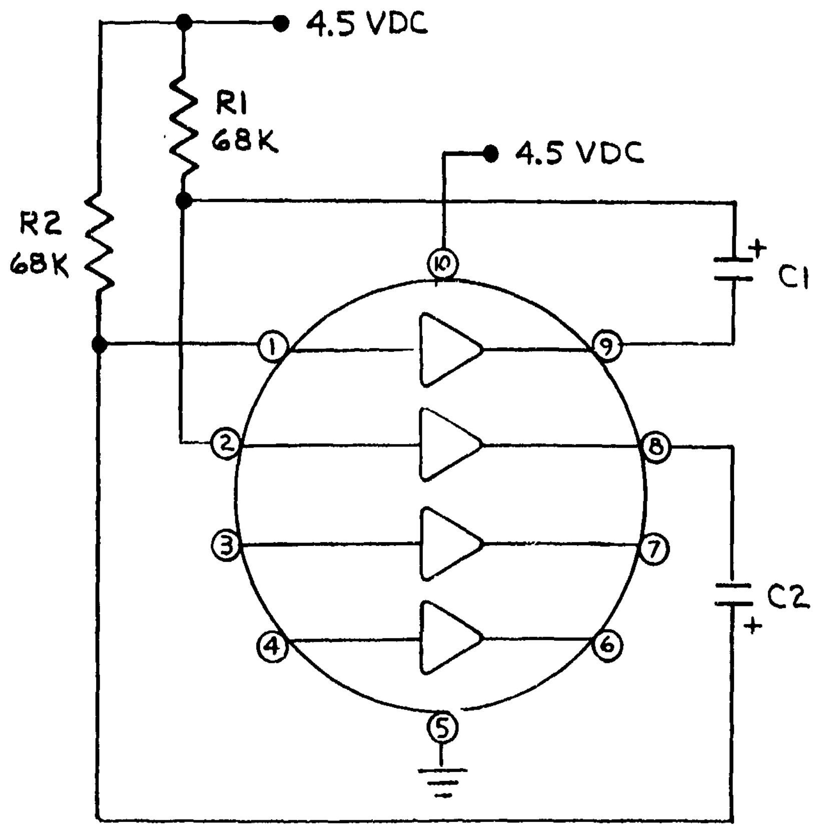



Figure 12. 4 Hz Micrologic Clock (Fairchild 929 Inverter)

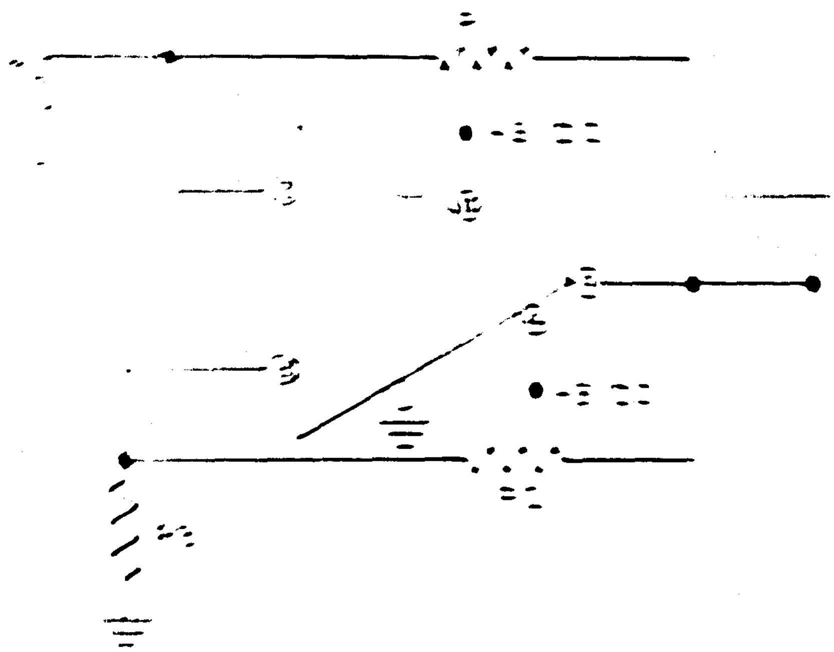


Figure 13. Operational Amplifier Clock

Next, an RCA [illegible] micrologic operational amplifier with a capacitor connected to the inverting input, as shown in Figure 13, was tested. Output voltage of the operational amplifier is of the opposite polarity as the input voltage. The capacitor prevents the input from changing as rapidly as the output, thereby allowing the circuit to operate as a flip-flop. With a nominal frequency of 25 Hz, the output varied only 0.6 Hz (2.4%) over the temperature range of -40°C to +70°C. As can be seen in Figure 13, this circuit requires a positive as well as negative power supply for operation. Stability is obtained, but at the expense of an additional power supply.

To avoid the difficulties with temperature instability of micrologic elements, a discrete component flip-flop was tested next. Figure 14 is a circuit for a flip-flop with an asymmetrical output. As the base voltage of Q1 increases, Q1 switches from a non-conducting state to saturation. The collector of Q1 is coupled to be base of Q2 which falls below

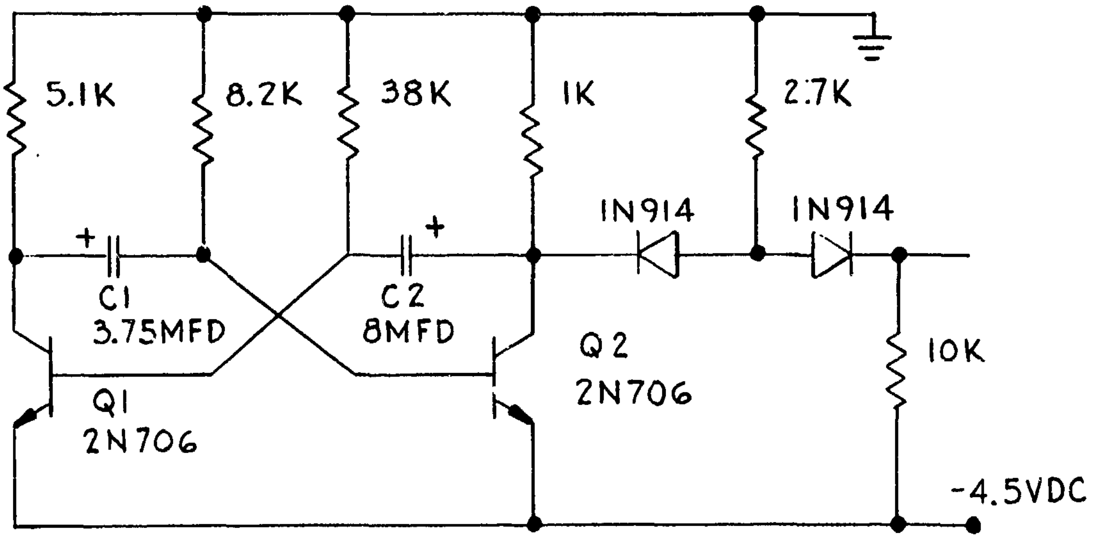



Figure 14. Asymmetrical Flip-Flop Clock

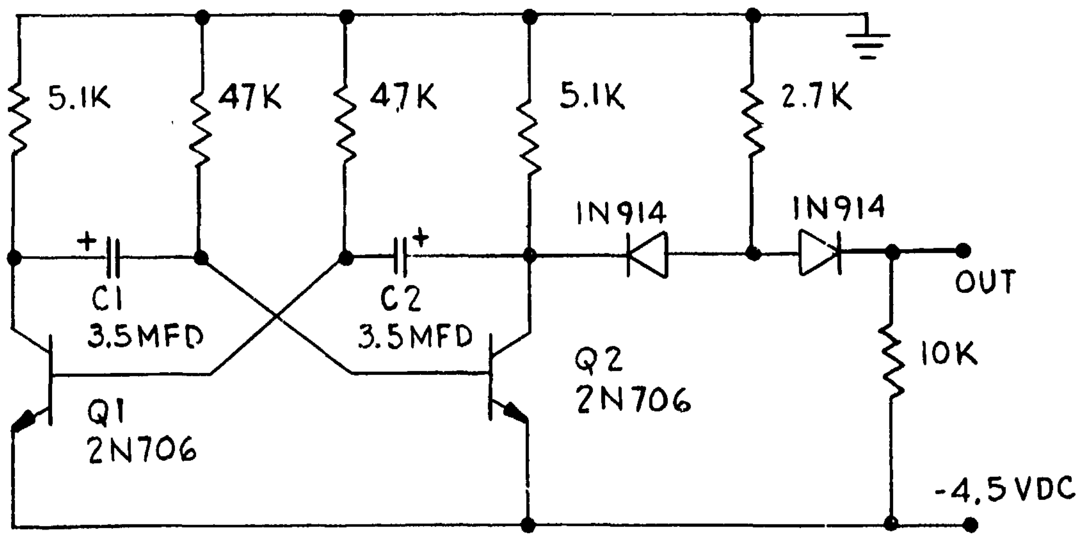



Figure 15. Symmetrical Flip-Flop Clock

cutoff when Q1 saturates. Collector of Q2 rises which drives Q1 further into saturation. This state continues until Q2 goes into saturation by the charging of C1.

This circuit exhibited only a 0.02 Hz variation over the temperature range of -40°C to +70°C. However, the exponential rise of the 20 millisecond pulse is unsuitable for triggering micrologic elements and current drain is high (8.0 ma).

The output was changed to a square wave by slight modification to the circuit (refer to Figure 15). The frequency varied from a low of 4.00 Hz at 70°C to 5.00 Hz at -40°C. Although the temperature stability was not as good as the circuit shown in Figure 14, voltage stability was better.

A summary appears in Table I for comparison of the various circuits.

The symmetric flip-flop was selected since it has low current drain and good voltage stability.

Table I.

| Circuit | Temperature Variation -40°C to +70°C | % Voltage Variation 3.0 V to 5.0V | Current Drain at -4.5 V | Comments |
|---|---|---|---|---|
| Fairchild Micrologic dual 2-input | 500 | 5.3 | 20 ma | Unstable. High current drain. |
| Fairchild Micrologic Quad Inverter | 35 | 5.3 | 30 ma | Unstable. High current drain. |
| RCA Micro-logic Operational Amp. | 2.4 | 11.3 | Did not measure. | Need two voltage sources. |
| Flip-Flop Asymmetric | 0.5 | 4.5 | 8 ma | High current drain. 20 ms pulse not suitable for blanking. |
| Flip-Flop Symmetric | 12.5 | 1.25 | 1 ma | Fairly stable. Low current drain. |

b. Sequencer

The sequencer consists of two Fairchild micrologic flip-flops and two 914 micrologic gates. Each 923 micrologic element divides the output of the clock by two. Thus, outputs are available at 4 Hz, 2 Hz, and 1 Hz. By combining the 2 Hz and 1 Hz outputs with the 914 micrologic "AND" gates, four pulses are available with 250 millisecond duration. These pulses are used to "turn on" the switching transistors. The "ON" transistor determines which sensor resistor is being used to control the frequency of the met pulse generator. The pulses also give the proper sequence for the meteorological pulse generator; reference, temperature, humidity, and spare channel.

A 20 millisecond monostable multivibrator is slaved to the 4 Hz clock to provide blanking pulses. When the commutator switches from one sensor to the next, the output of the meteorological pulse generator is prevented from modulating the 1.68 GHz transmitter. See Figure 16 for the timing diagram of the solid state commutator.

c. Switching Transistors

The meteorological sensing elements must be switched in the time constant circuit of the meteorological pulse generator. This can be accomplished with reed relays or switching transistors. Reed relays have almost zero contact resistance when "ON" and almost infinite back resistance when open. They would be ideal for use in the radiosonde applications except for two major disadvantages:

1. Contact bounce

2. High coil power needed for operation.

The contacts in a reed relay are springs which distort in the presence of a magnetic field. The force experienced by the contacts when closing is sufficient to cause the contacts to make and break several times before remaining closed. During this period of contact bounce (2 or 3 milliseconds), the sensor resistor would be switched in and out of the meteorological pulse generator circuit causing erratic operation.

A coil is needed to furnish the magnetic field for the reed relays. During the time a relay is energized, the coil must dissipate power (approximately 0.5 watt). This power drain would necessitate a large battery for the sonde. A latching

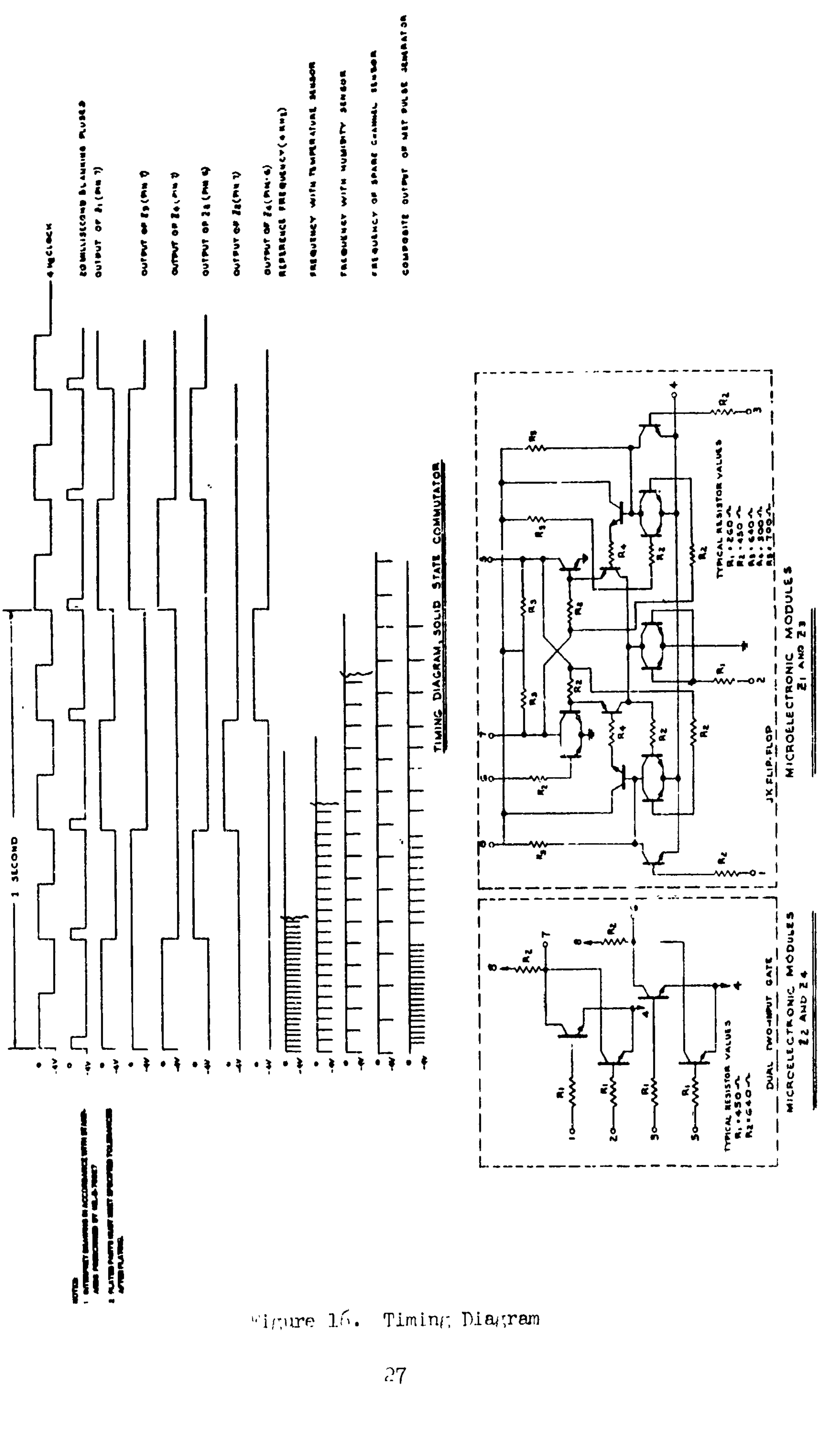



Figure 16. Timing Diagram

reed relay could be used, but at added expense. Several types of switching transistors were tested in conjunction with the meteorological pulse generator to find a suitable switching transistor. Rather than attempting to measure the "ON" resistance of a transistor which could vary considerably, a comparison was made of meteorological pulse generator frequency with a toggle switch and various transistor switches. The frequencies were selected by means of a variable resistance in the time constant circuit of the meteorological pulse generator. The same value of resistance for a given frequency with the toggle switch was used to obtain the frequency reading with the various transistors tested.

Shunting the meteorological pulse generator with an "open" transistor did not produce any frequency shift for any of the above transistors.

Table II.

| Frequency (Hz): | 4,000 | 3,000 | 2,000 | 1,000 | 500 |
|---|---|---|---|---|---|
| Switch Type: | | | | | |
| Toggle Switch | 4,000 | 3,000 | 2,000 | 1,000 | 500 |
| 2N2905A | 4,000 | 3,000 | 2,000 | 1,000 | 500 |
| 2N3638 | 4,000 | 3,000 | 2,000 | 1,000 | 500 |
| 2N3903 | 3,996 | 2,997 | 1,998 | 999 | 499 |

Table II indicates either a 2N2905A or 2N3638 transistor could be used without introducing error. However, these are p-n-p units and two transistors would be required per sensor due to the fact that the sensors must be switched to -4.5 volts. The 2N3903 unit is n-p-n, so only one of these per sensor is necessary for switching.

See Figure 17 for the switching transistors circuit.

The two Hz errors introduced by the 2N3903 results in a maximum temperature error of 0.1°C at 40°C. This is much less than the error introduced by truncating the temperature-reference ratio at three decimal places in the data processor. The truncating error for three decimal places is 0.17°C, which corresponds to a 4 Hz frequency change.

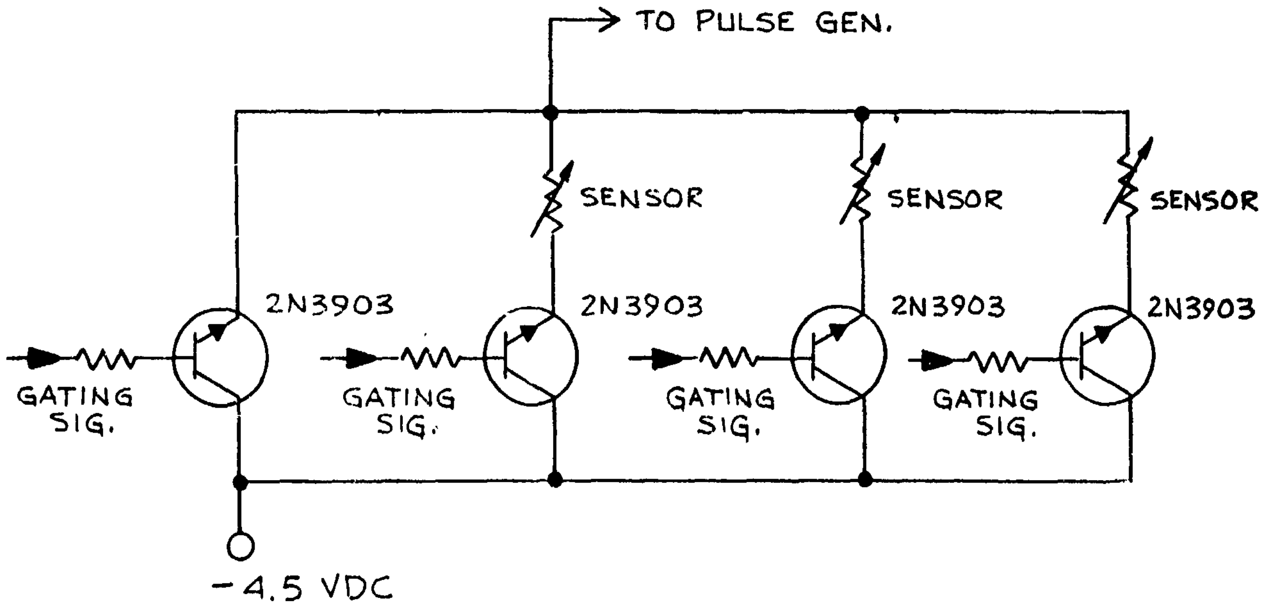



Figure 17. Switching Transistor Circuit

$$\text{Example:} \quad \frac{2{,}000}{4{,}000} = 0.500$$

$$\frac{2{,}004}{4{,}000} = 0.501$$

Therefore, any frequency change less than 4 Hz results in no change in the ratio punched out by the Meteorological Data Processor.

In addition, the ML 419 thermistor to be used has an accuracy of ± 0.5°C. Thus, the error introduced by the switching transistor is negligible.

Resistance of the ML 476 humidity element depends upon air temperature as well as relative humidity. Maximum error introduced by the switching transistor is 0.2% relative humidity at 25°C. The error introduced by truncating the humidity-reference ratio at three decimal places results in an error of 0.4% relative humidity. Accuracy of the humidity sensor is ±5% relative humidity for humidities less than 20%. Again, the error introduced by the switching transistor is negligible. Refer to Figure 18 for the audio curve.

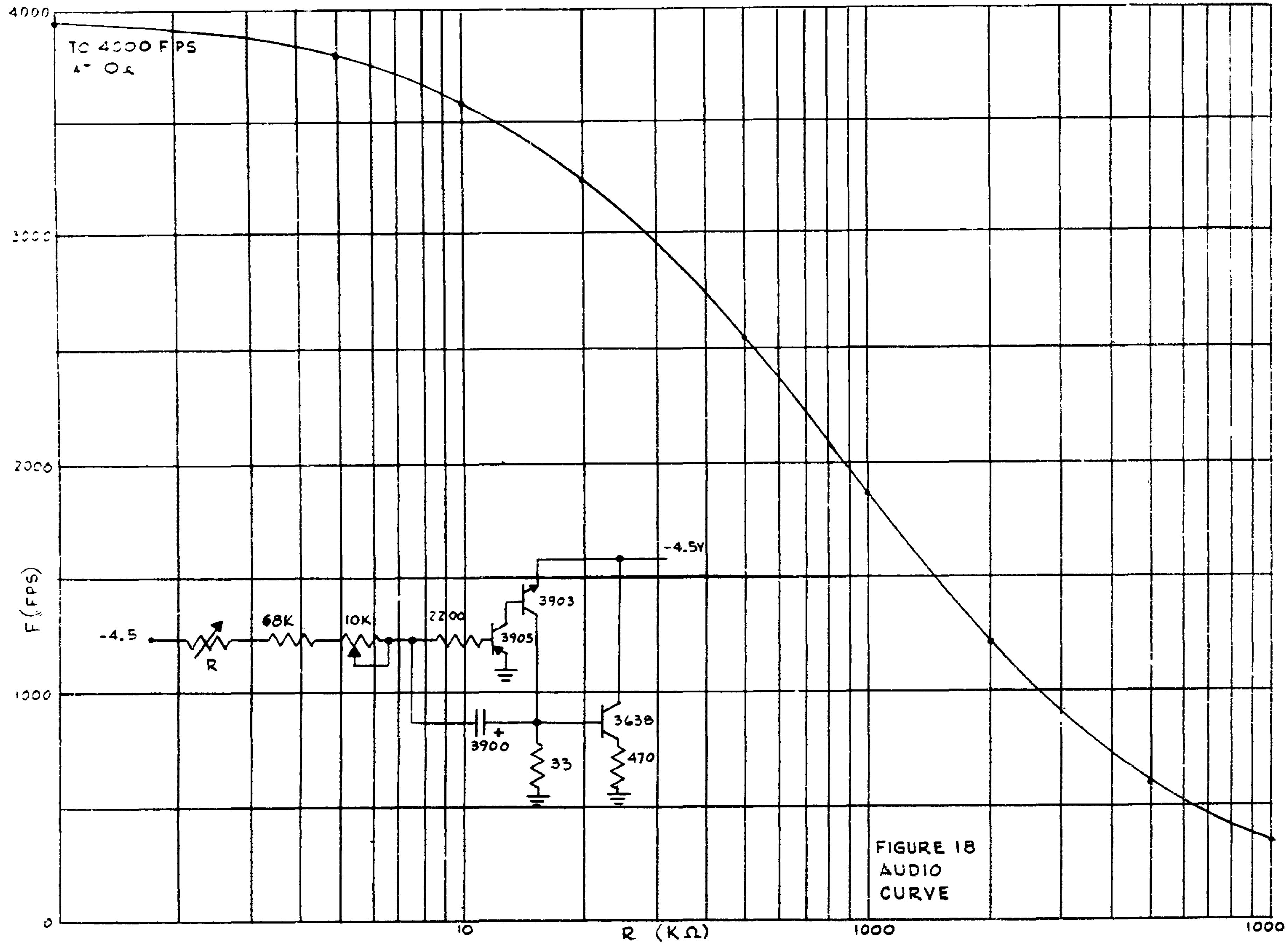



FIGURE 18
AUDIO
CURVE

## 4. 1.68 GHz Transmitter

Originally four types of transmitters were considered:

a. Tunnel Diode Fundamental

b. Transistor Fundamental

c. Transistor with Multiplier

d. Vacuum Tube

The maximum power that could be realized from a tunnel diode with reasonable current drain (200 ma) would be 12.5 mw. While this transmitted power would be sufficient under ideal propagation conditions, it would be marginal and provide unreliable communications under normal atmospheric conditions.

Microwave printed circuits can be used as the resonant circuit in microwave oscillators. The oscillator circuit is basically a tuned collector-tuned base circuit with the transistor operating in a common collector configuration. Figure 19 shows the equivalent circuit.

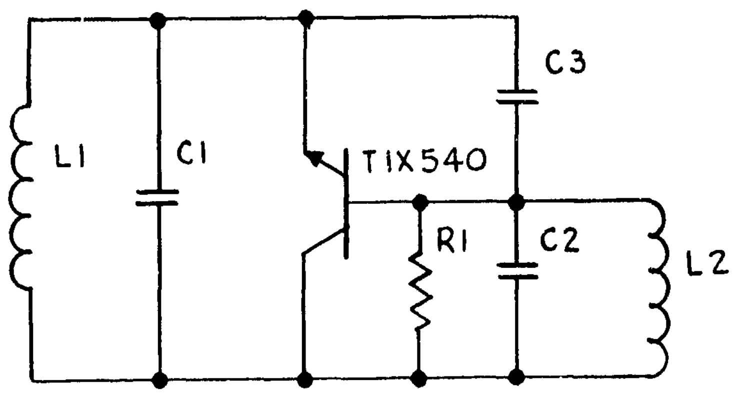



Figure 19. Equivalent Circuit

The resonant circuit composed of L1 and C1 can be represented by a transmission line which is 1/4 wavelength at the resonant frequency. (The emitter-collector capacitance is small enough to be neglected.) C2 is the collector-base capacitance, therefore, the base circuit can be made resonant at the desired frequency by adding an inductive transmission line. The condition for parallel resonance dictates that $(X_C)$ must equal $(X_L)$ at resonance. A shorted ideal transmission line has an input impedance which is purely inductive and expressed by the equation:

$$Z_{IN} = j Z_0 \tan \beta \ell$$

where: $Z_0$ = characteristic impedance

$\beta$ = phase constant = $\frac{2\pi}{\lambda}$ for an ideal line

$\ell$ = line length.

The collector base capacitance can be determined from the transistor specification sheet and the $(X_C)$ can be calculated from:

$$(X_C) = \frac{1}{\omega C}$$

then $(X_C) = (X_L) = (Z_{IN}) = Zo \tan \beta\ell$ and $\ell$ can be determined.

C3 is the emitter-base capacitance and provides the feedback path. R is the load presented to the transistor and is determined by the value and the position of the external load from the shorted end of the collector-base transmission line. If the external load is known the position of the power tap from the shorted end of the line can be determined from the equation:

$$\text{External load} = R \sin^2 B\ell_T$$

where $\ell_T$ is the length of line from the shorted end of the base collector line and R is the load presented to the transistor.

The physical layout of the board follows a design built by Texas Instruments. The configuration is a micro strip on 1/8" "Rexolite 2200." The design calculations were based on the 2.62 dielectric constant of "Rexolite 2200." However, due to the unavailability of "Rexolite 2200," "Custom Poly CR" was used. "Custom Poly CR" has

has dielectric constant of 2.7, therefore, the actual frequency was lower than the design frequency. Figure 20 shows the board. (A half wavelength has been added to the collector-base line to give a workable dimension.)

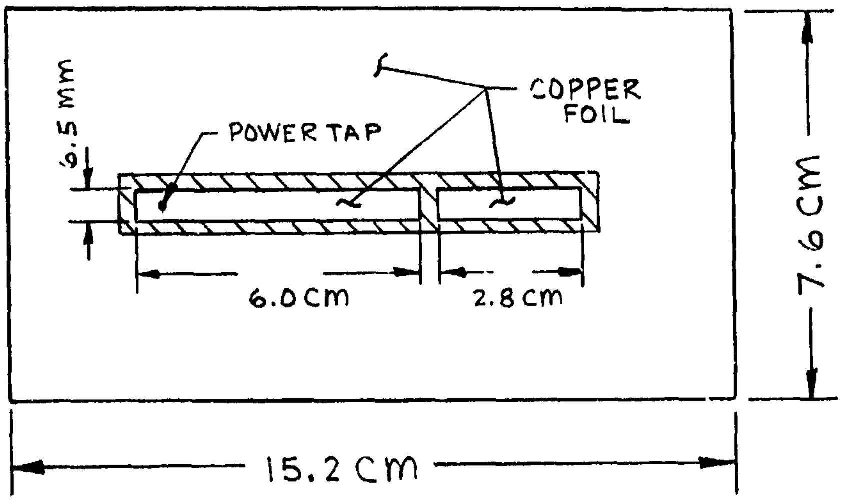



Figure 20

Calculations indicated that the power tap should be 1/8" from the end of the line to produce maximum power output from the transistor. However, on the test model the tap was closer to 3/16" from the end of the line. This made it necessary to use a 3-stub impedance match to make the transistor produce appreciable power.

The test model oscillated at 1.62 GHz and produced 150 mw output when Vce = 25 volts and Vcb = 15 volts. When the voltage was raised to Vce = 32.5 volts and Vcb = 20 volts, the power output was 225 mw and the frequency was 1.63 GHz.

The physical configuration of this unit does not lend itself to the payload restrictions imposed by the Cricket Rocket, however, although there are techniques available for reducing the size of stripline devices, the cost of dielectric materials to achieve this is quite high and the amount of development required to

optimize the circuit was felt to be out of line with the intent of the project.

Transistor oscillators with multiplier are already on the market (RCA, Western Microwave Laboratories, and Frequency Sources, Inc.) and are now being employed in several types of meteorological devices. Although these are currently quite expensive, the price is expected to drop to around $15.00 within the next two years.

These solid state transmitters are characterized by their small size, rugged construction and minimal power supply requirements. For these reasons, this type of transmitter is ideally suited to the recoverable rocketsonde design.

Any comparison of transmitter devices for the radiosonde design must, of course, include an analysis of the vacuum tube cavity oscillator. While it is true that the vacuum tube transmitter costs considerably less than solid state devices at the present time, several additional features of the tube must be considered. In the first place, the tube requires more power than the transistor device. In fact, the filament power alone is not much less than the total power required for the solid state transmitter. The tube also requires a plate voltage supply so that the power supply for a tube type transmitter must be larger and more expensive. Some reduction in size can be achieved by using a dc-dc converter to obtain the plate voltage rather than a B battery section, because the dc-dc converter components and added capacity in the low voltage battery require less volume than a practical B battery. This is the design approach that would have to be taken for the rocketsonde where space is at a premium. However, a dc-dc converter circuit including transformer, switching transistors and associated circuit components would add approximately $17.00 to the cost of a tube-type transmitter. The tube has thus lost its only advantage, cost, when considering the development of new radiosondes where volume must be minimized.

Since the currently available transistor oscillator-multiplier device is the choice for the rocketsonde, it will also be used in the balloonsonde so that the two sondes will be as nearly alike as possible. If the tube-type transmitter were to be used for the balloonsonde, a different battery would be required as discussed above. In addition, however, changes would be required to other parts of the circuit. For example, with the solid state transmitter, the remainder of the circuit is designed to operate from a negative supply, while the tube transmitter, the remainder of the circuit should properly be designed to operate from a positive supply. While this is not difficult, it does represent a difference in design. Also, the pulse signal level required to modulate the two types of transmitters is different which would necessitate other circuit changes.

The RCA S190 solid state power source has been chosen since it is the least expensive of the devices presently available. The standard S190 supplies at least 200 mw of power at 1.68 GHz at 25°C. The device is temperature-compensated to be frequency stable within .4 MHz over the operating temperature range of 0° to 70°C. Operation is possible below -30°C at the expense of additional frequency shift. It is pointed out, however, that the temperature range to which a sonde will be exposed during a particular flight is small so that the change in frequency during a flight will not be appreciable.

The S190 features a compact (1" diameter X 1.4" length), rugged package which is capable of withstanding a shock of 1600 g's for 2 milliseconds, an acceleration of 200 g's for 10 seconds, and a vibration of 20 g's from 20 to 2,000 Hz during operation, with negligible frequency or power changes. The operating frequency can be shifted ± 10 MHz by means of a single tuning screw accessible from the side. Provisions are included for frequency and ON-OFF pulse modulation. The S190 is designed for 18-volt operation to achieve optimum utilization of battery weight and space allocation.

The frequency stability of the standard S190 is less than 2 MHz shift with voltage changes from -12.5 to -11.5 volts.

See Figures 1 and 2 for a comparison of the batteries operated under simulated load conditions.

6. Sensors

The ML-419 Temperature Sensor and the ML-476 Humidity Sensor are used in both the Cricketsonde and the Balloonsonde as specified in the project work statement.

7. Antennas

The Transmitting Antenna will be a one-quarter wave dipole with a one-quarter wave counterpoise. The antenna system has a characteristic impedance that is very close to 50 ohms, thus providing a good match to the 50 ohm output impedance of the 1.68 GHz solid state power source. The VSWR will not exceed 1.5, thereby minimizing losses in the antenna system.

The receiving antenna is a 1/4 wave length insulated conductor for the balloon package. The antenna is extended and attached to the lanyard prior to launch. For the rocketsonde package, before launch, the receiving antenna is tied to the parachute lanyard, folded and packed along with the parachute, in the parachute compartment. At apogee, the antenna is fully extended as the parachute is deployed.

8. Power Terminator

In order to prevent interference from a previously released sonde when several sondes are launched in quick succession, a power termination device is provided. Two mechanical timers were investigated for this purpose. One is the same timer used in the Cricket Rocket to deploy the parachute at apogee, but modified so that it could be set for any time delay up to ten minutes; the other is a Swiss-made pocket timer that provides up to a two-hour delay and is distributed in the United States by an electronics supply house. Contact with the vendors indicated that the Cricket-type timer would be less expensive than the pocket timer. It has, therefore, been selected for use in the sonde design.

In addition to the cost advantage, the Cricket-type timer already incorporates a "g" switch that would be required for the rocket application and has proved that it can withstand the rocket-environment. For balloonsonde use, the "g" switch can be tripped manually just prior to launch.

Refer to Figures 21, 22 and 23 for the mechanical assembly drawings of the radiosonde and the sensor package and the complete schematic of the unit.

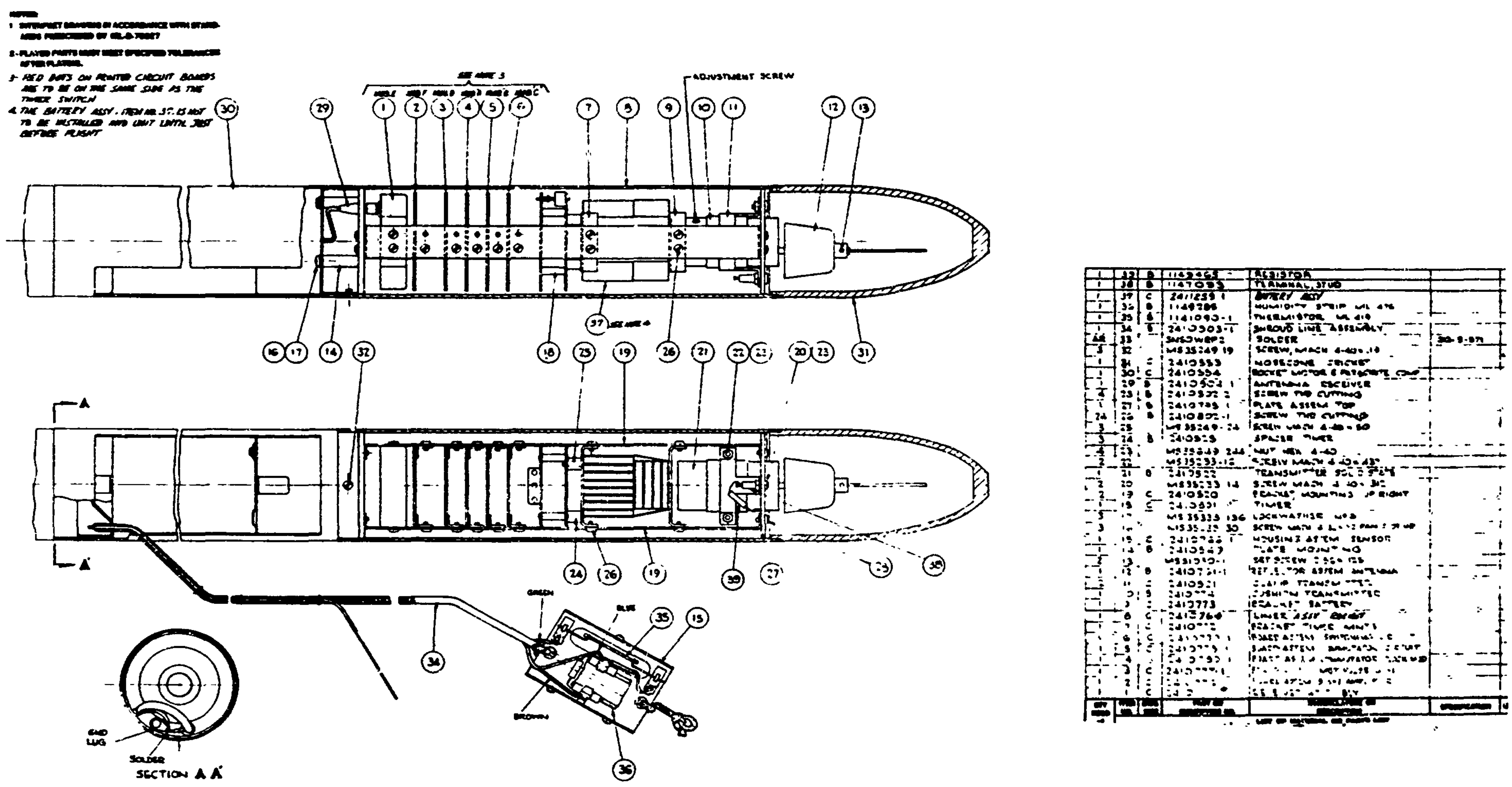
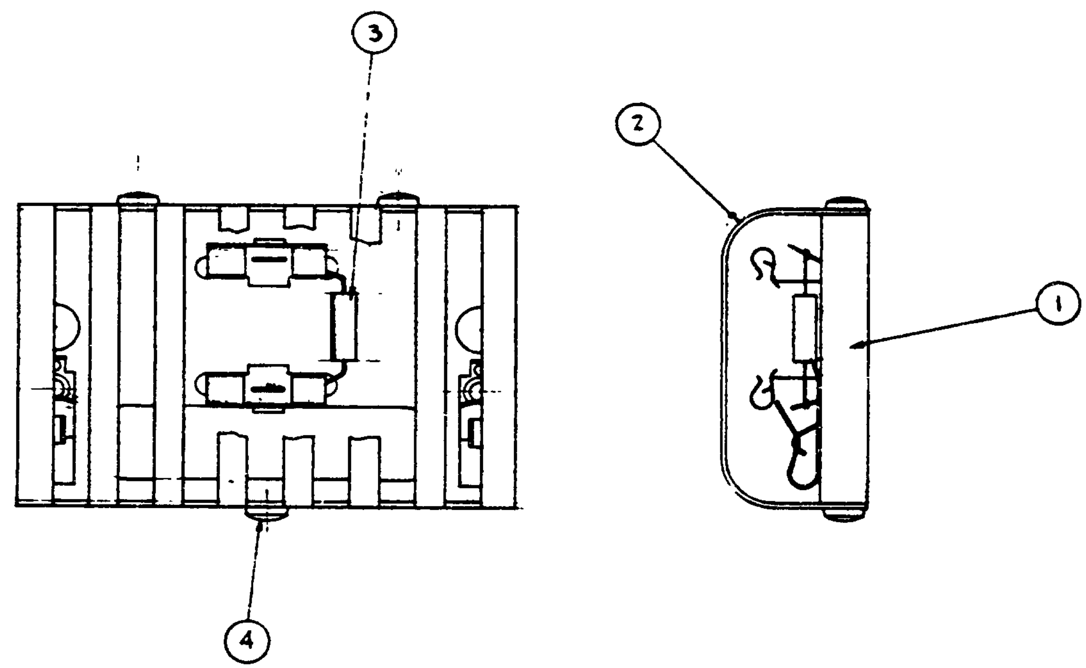



Figure 21. Low Level Radiosonde Mechanical Assembly

NOTES:

1 - INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL-D-70327

2 - PLATED PARTS MUST MEET SPECIFIED TOLERANCES AFTER PLATING.




| QTY REQD | ITEM NO | DWG SIZE | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION |
|---|---|---|---|---|
| 3 | 4 | | MS 35233-12 | SCREW MACH [illegible] |
| 1 | 3 | | RC07GF245J | RESISTOR [illegible] W |
| 1 | 2 | C | 2410[illegible] | COVER, SENSOR HOUSING |
| 1 | 1 | C | 2410[illegible]25-1 | HOUSING ASSEM SENSOR |

Figure 22. Mechanical Assembly Sensor Package

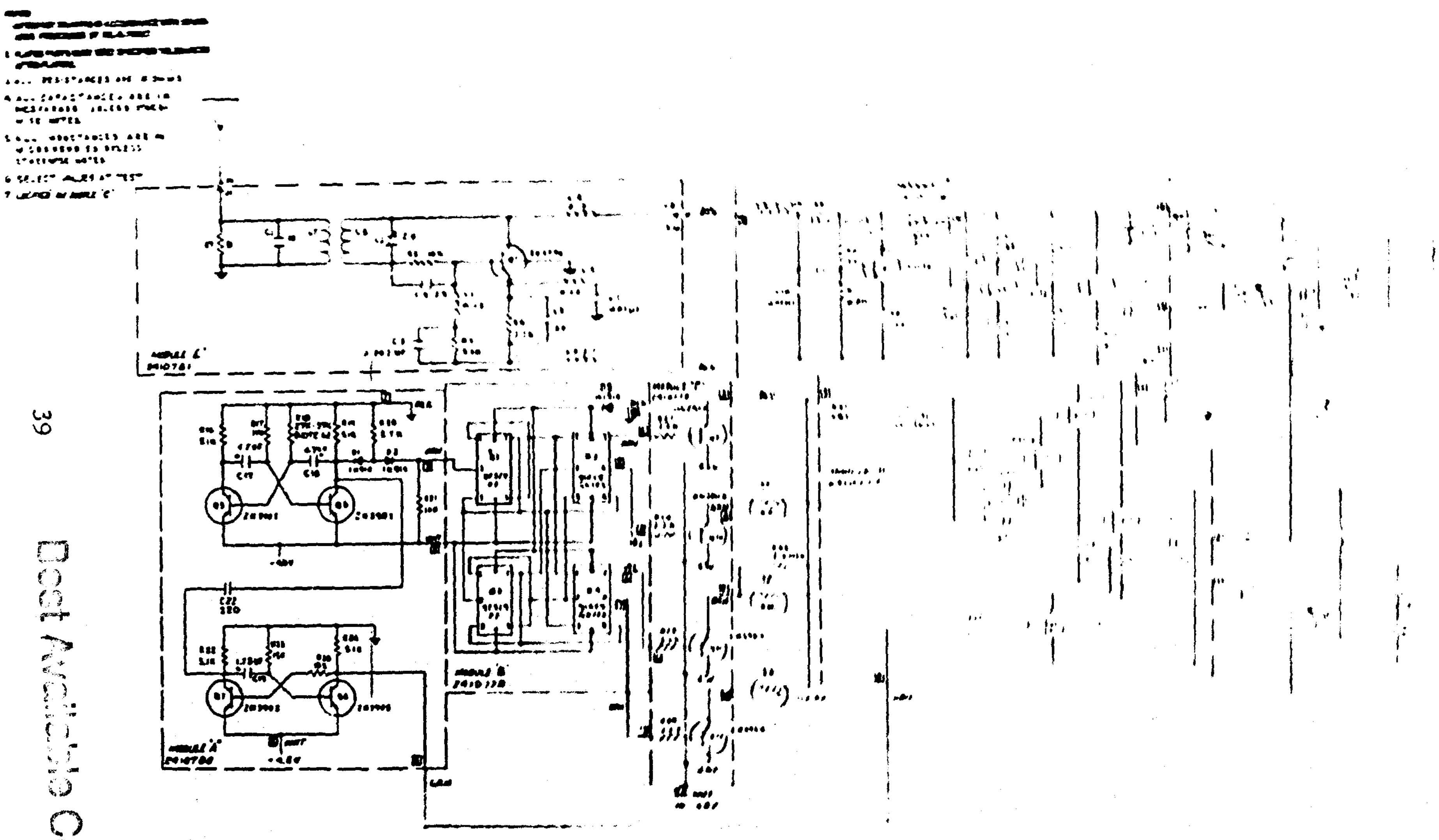


Figure 23. Schematic Diagram

## E. AN/GMD-4 DATA PROCESSOR MODIFICATION

### TELEDYNAMICS MET. DATA PROCESSOR

1.0 Purpose

The purpose of this specification is to describe those changes required in the Teledynamics Meteorological Data Processor to make it compatible with the Low-Level Radiosonde.

2.0 Modifications

2.1 Cabinet Modifications

2.1.1 Voltage-Controlled Oscillator

Purpose - To provide power to the additional circuitry located on the modified VCO card.

Modification - Connect a wire from Pin E on the VCO connector to the most convenient + 15 volt terminal.

2.1.2 Integrating Amplifiers

Purpose - To change time constants and gain of integrating amplifiers.

Modification - Install a rotary switch on the Processing Drawer close to operational amplifiers 1 and 2. Wire as shown in Figure 24.

2.1.3 Purpose - To reduce met. data pulse from receiver to 100 usec.

| Remove | Add |
|---|---|
| C 1022 from V1008 pin 1 | C1022 to contact A of DPDT switch; common terminal of switch to V1008 pin 1; add capacitor C1022A (62 pf); one side to V1008, pin 7, other side to contact B of switch. See Figure 25. |

Add a wire between J-205, pin 7 and J-206, pin 15.

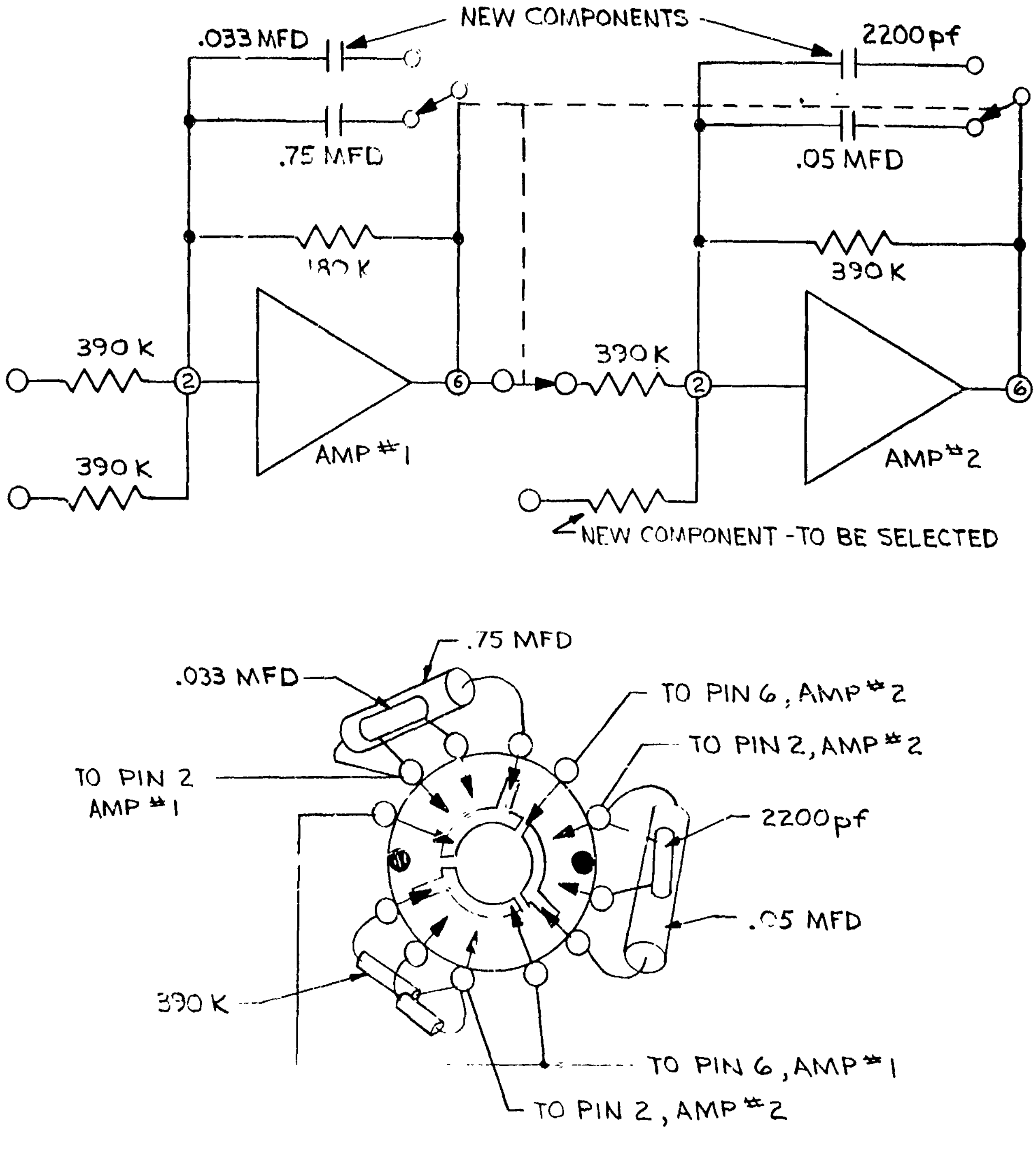



FIGURE 24

INTEGRATING AMPLIFIER MODIFICATION

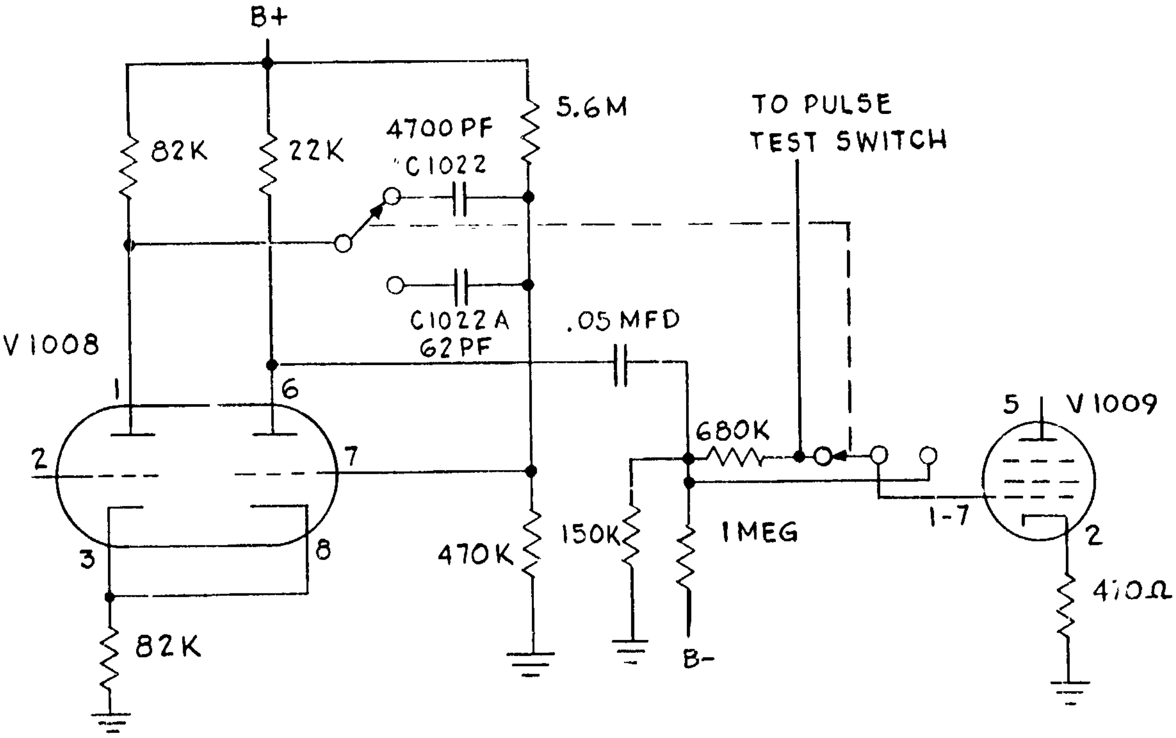



FIGURE 25

RECEIVER MODIFICATION

2.1.4 Purpose - Addition of a counter to provide a 1 KHZ counting signal to the Reference Detector counter.

Modification - Add the following wires: (See Figure 26)

| | | |
|---|---|---|
| J203N | to | J215-B |
| J215-2 | to | J218-B |
| J218-F | to | J208-4 |
| J208-2 | to | J215-P |
| J215- P | to | J215-C |
| J215- C | to | J215-13 |
| J215-13 | to | J215-J |
| J215-J | to | J218-J |
| J218-J | to | J222-N |
| J218-18 | to | J215-12 |
| J215-12 | to | J215-1 |

2.1.5 Purpose - To modify the counter in the pulse standardization circuit.

Modification - Add a wire from J205-4 to J206-15.

2.2 Card Modifications

2.2.1 Pulse Standardization

Purpose - To modify counter in Pulse Standardizer circuitry so that a reset is initiated after counting Forty-three 200 KHZ pulses instead of eight hundred sixty 200 KHZ pulses as presently required.

Modification

Card J204; Remove wire from pin P to CR5, add wire from CR5 to pin J.
Card J205; Remove wires from pin P to CR5,

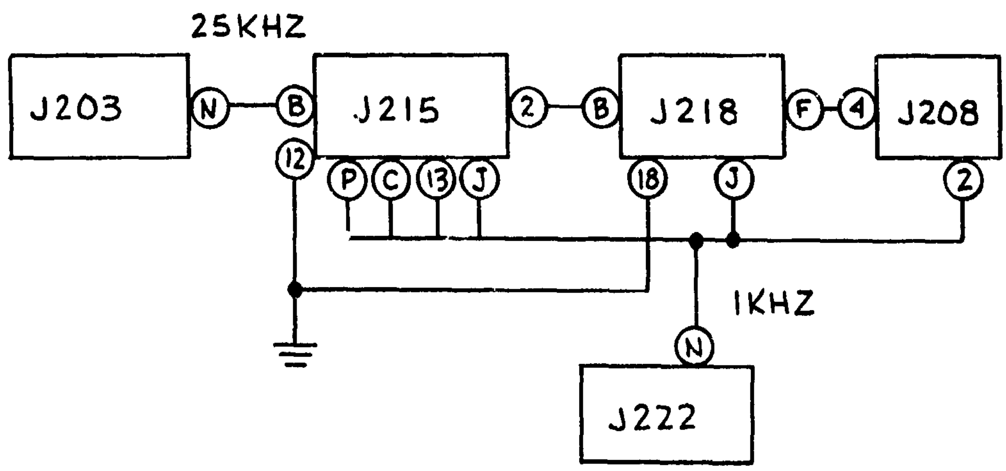



FIGURE 26

ADDITIONAL COUNTER TO PROVIDE A 1KHZ
SIGNAL TO REFERENCE DETECTOR

CR12 to pin C, and CR26 to pin 12. Add wires between CR5 (cathode) and pin J, cathodes of CR12 and CR26 to pin 13.

Isolate pin 2 from circuitry.

Isolate pin H from circuitry.

Add a wire between TP2 and pin 2.

Ca J206; This will be a blank jumper card.

Add wires between pin B and pin H, and between pin 15 and pin 7.

Card J208; Remove C5 (.01 ufd). Replace C5 with .0022 ufd.

2.2.2 Meteorological Data Envelope Detector - J209

Purpose - Reduce the integrator time constant from 350 usec to 17.5 usec. Reduce the pulse width of the one-shot delay generator from 3.0 seconds to 0.15 second.

Modification - Replace C10 (2.7 ufd) with 0.135 ufd. Replace C4 (50 ufd) with 2.5 ufd.

2.2.3 Missing Channel Detector - J210

Purpose - Reduce integrator time constant by a factor of 20. Reduce period of delay generator to .3 seconds.

Modification - Replace C5 (3.3 ufd) with 0.165 ufd. Replace C5 (20 ufd) with 2.7 ufd.

2.2.4 Digital Reference Detector

Purpose - To increase the counting rate from 50 HZ to 1000 HZ. This will be accomplished by utilizing the 25 KHZ output on J203, adding a five-stage counter, and utilizing a spare one shot on J208. The new counter will be preset to a count of seven and after twenty-five additional counts will trigger the one-shot which will serve as the input to the Digital Reference Detector and as the reset signal to the new counter.

Modification - Add Binary Counter cards, Sonex type 2106-D (Dwg. No. 2217) in slots J215 and J218. No modifications are required on these cards.

Card J208 - Remove C11 (.01 ufd). Replace C11 with .0025 ufd.

Card J222 - Remove CR10 from pin 7. Add wire from CR10 to pin N.

2.2.5 Fall-out Detector During Reference Gate, J211

Purpose - To reduce the time constants in the integrator circuit by a factor of twenty. Reduce the period of the time delay generator from 1.5 seconds to 75 milliseconds.

Modification - Replace C2 (0.68 ufd) with .033 ufd. Replace C4 (20 ufd) with 1 ufd.

2.2.6 Reference Detector, Storage and Regeneration

Purpose - Modify BCD Reference Counter to generate a reset after accepting 1000 pulses. Change the counting frequency from 12.5 KHZ to 50 KHZ. Reduce time delay of one-shot J222-F from 1.5 seconds to 60 milliseconds.

Modification - Card J226: Replace with jumper card with pin B and pin 2 connected.

Card J203 - Isolate pin 2. Connect pin 2 to TP2.

Card J222 - Replace C7 (20 ufd) with 1.0 ufd capacitor.

2.2.7 Temperature, Humidity, and X-Channel Counters

Purpose - The tens, hundreds, and thousands positions of the counters are now being sampled by the output circuits and the data is punched on paper tape. The modification will provide sampling of the units tens, and hundreds positions of the counters.

Modification - Cards J1, J5 and J30: Replace with jumper cards with pin B and pin 2 connected.

2.2.8 Modification to Timing for Punch Rate

Purpose - Maximum punch rate is now once every 6 seconds. The new punch rate must be once per second. Card J102 must be modified to divide by 2 and Cards J103 and J105 must be modified to divide by 25.

Modification - J102 - Isolate pin H. Add a wire between pin H and pin F.

J103 - Remove CR12 from pin C. Add jumper from CR12 to pin P.

J105 - Remove CR5 from pin P. Add jumper from pin 12 to cathode of CR5.

Isolate pins N and 14 from circuitry. Add jumpers between pins N and F and pins 14 and 6.

2.2.9 Programming Connector

Purpose - To provide substitute Program Connectors P93 and P193 so that the programming of the MDP will be compatible with the Low Level Radiosonde.

Modification - See Tables I and II for wiring information of P93 and P193.

## TABLE I. WIRING FOR P93 IN GROUPS

| Group | | |
|---|---|---|
| I. | 7-13 | 1-17 |
| | 13-14 | 2-18 |
| | 14-15 | 3-78 |
| | 15-21 | 5-25 |
| | 21-22 | 76-26 |
| II. | 8-23 | 17-27 |
| | 23-66 | 72-78 |
| | 66-67 | 4-71 |
| | 67-73 | 25-70 |
| III. | 29-30 | 35-27 |
| | 30-31 | 36-18 |
| | 31-32 | 37-72 |
| | 32-33 | 38-71 |
| | 33-34 | 39-70 |
| | 34-77 | 40-26 |
| IV. | 10-41 | 36-45 |
| | 41-42 | 37-46 |
| | 42-43 | 38-47 |
| | 43-44 | 39-48 |
| V. | 11-49 | 35-54 |
| | 49-50 | 55-45 |
| | 50-51 | 46-56 |
| | 51-52 | 47-57 |
| | 52-53 | 48-58 |
| VI. | 12-28 | 54-62 |
| | 28-59 | 55-63 |
| | 59-60 | 56-64 |
| | 60-74 | 57-65 |

Table 2. Wiring for P193

| | |
|---|---|
| Wire 70 to 74 | Spare Channel in Block No. 3 |
| 77 to 73 | Humidity Channel in Block No. 1 |
| 76 to 71 | Temperature Channel in Block No. 2 |
| Wire 14 to 4 | Space after Humidity |
| 13 to 7 | Space after Humidity |
| Wire 15 to 8 | Space after Temperature |
| 16 to 2 | Space after Temperature |
| Wire 39 to 15 | Space after Spare Channel |
| 38 to 34 | Space after Spare Channel |
| Wire 17 to 10 | Space after Range |
| 18 to 1 | Space after Range |
| Wire 20 to 17 | Space after Elevation |
| 36 to 38 | Space after Elevation |
| Wire 22 to 11 | Space after Hz |
| 21 to 36 | Space after Hz |
| Wire 25 to 12 | Carriage Return |
| 26 to 5 | Carriage Return |
| Wire 23 to 25 | C/R |
| 24 to 21 | C/R |
| Wire 27 to 37 | L/F |
| 28 to 18 | L/F |
| Wire 32 to 27 | Seq. Stop Gate |
| 33 to 28 | Seq. Stop Gate |

## VOLTAGE CONTROLLED OSCILLATOR

The requirements for the Voltage Controlled Oscillator in the Low Level Sounding System are to oscillate over a frequency range of zero to 20 KHZ with an input voltage range of zero to +10 volts, and to provide a positive-going output signal. Since the VCO presently used has a maximum operating frequency of 10 KHZ, it is necessary to replace it with an oscillator which conforms to the new specification.

The Vidar VCO, Model 211-07, which has a frequency range of zero to 50 KHZ was selected as the replacement unit. The negative output of the Model 211-07 is converted to a positive pulse by a single-transistor level changing circuit. The frequency range is changed to zero to 25 KHZ by the addition of a flip-flop which is driven by the level changer. The frequency range is adjusted to zero to 20 KHZ by increasing the value of one of the operational amplifier summing resistors.

Complete information on the modification of the VCO card is given in The Bendix Corporation's Environmental Science Division drawing number 2410494.

# SONEX MET. DATA PROCESSOR

## 1.0 Purpose

The purpose of this specification is to describe those changes required in the Sonex Meteorological Data Processor to make it compatible with the Low Level Radiosonde.

## 2.0 Modifications

### 2.1 Cabinet Modifications

#### 2.1.1 Voltage-Controlled Oscillator

Purpose - To provide power to the additional circuitry located on the modified VCO card.

Modification - Connect a wire from pin E on the VCO connector to the most convenient + 15 volt terminal.

2.1.2 Purpose - To reduce met. data pulse from receiver to 100 usec.

Modification

| Remove | Add |
|---|---|
| C1022 from V1008 pin 1 | C1022 to contact A of DPDT switch; common terminal of switch to V1008 pin 1; add capacitor C1022A (62 pf); one side to V1008, pin 7, other side to contact B of switch. See Figure 27. |

2.1.3 Purpose - Addition of a counter to provide a 1KHZ counting signal to the Reference Detector counter.

Modification - Add the following wires: (See Figure 28).

J203-N to J216-B

J216-2 to J217-B

J217-F to J208-4

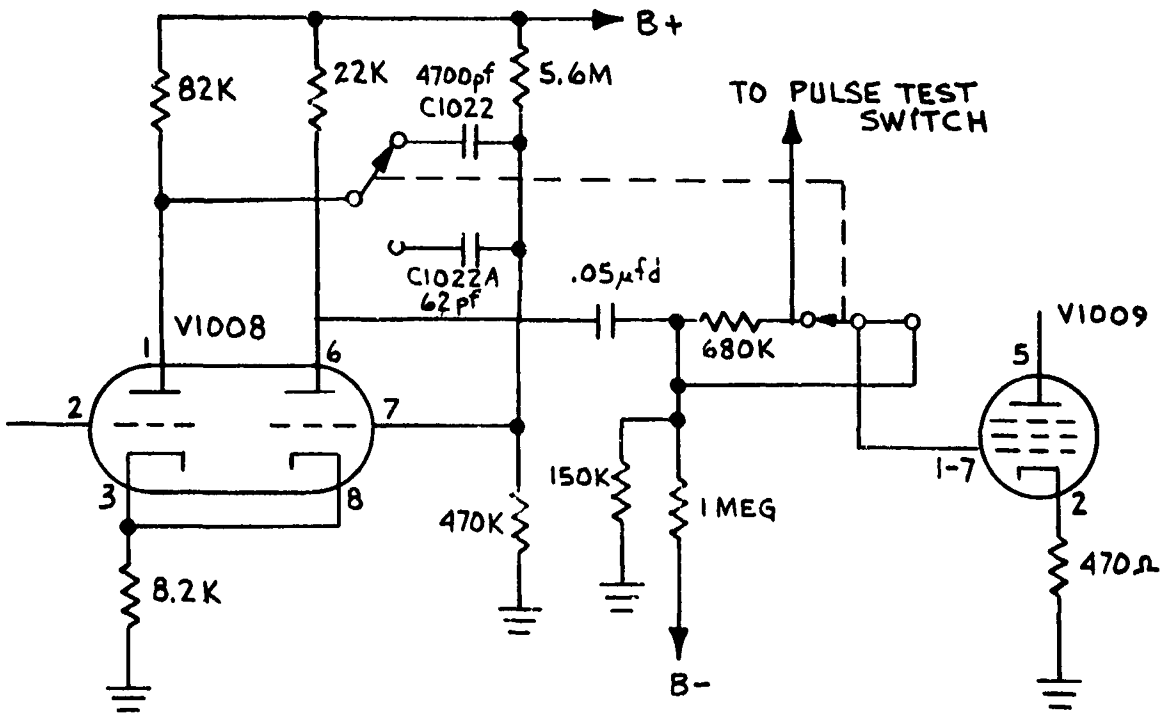



Figure 27.

Receiver Modification

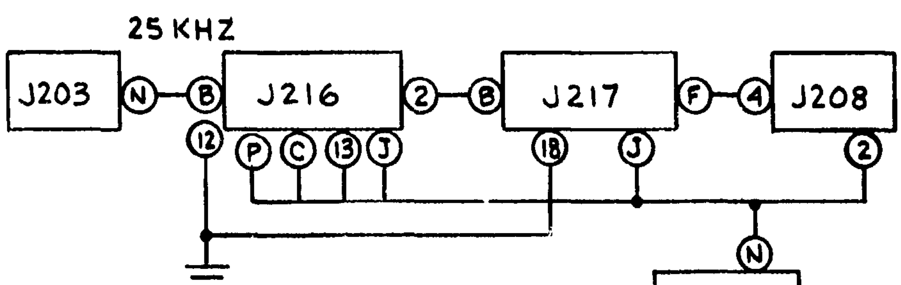



Figure 28.

Additional Counter to Provide a 1KHZ
Signal to Reference Detector

| | | |
|---|---|---|
| J208-2 | to | J216-P |
| J216-P | to | J216-C |
| J216-C | to | J216-13 |
| J216-13 | to | J216-J |
| J216-J | to | J212-7 |
| J217-J | to | J222-N |
| J217-18 | to | J216-12 |
| J216-12 | to | J216-1 |

2.1.4 Add a wire between J205, pin 7 and J206, pin 15.

2.1.5 Purpose - To modify the counter in the pulse standardization circuit.

Modification - Add a wire from J205-4 to J206-15.

2.2 Card Modifications

2.2.1 Pulse Standardization

Purpose - To modify counter in Pulse Standardizer circuitry so that a reset is initiated after counting forty-three 200 KHZ pulses instead of eight hundred sixty 200 KHZ pulses as presently required.

Modification - Card J204 - Remove wire from pin P to CR5; add wire from CR5 to pin J.

Card J205 - Remove wires from pin P to CR5, CR12 to pin C, and CR26 to pin 12. Add wires between CR5 (cathode) and pin J, cathodes of CR12 and CR26 to pin 13.

Isolate pin 2 from circuitry.

Isolate pin H from circuitry.

Add a wire between TP2 and pin 2.

| | | |
|---|---|---|
| J208-2 | to | J216-P |
| J216-P | to | J216-C |
| J216-C | to | J216-13 |
| J216-13 | to | J216-J |
| J216-J | to | J212-7 |
| J217-J | to | J222-N |
| J217-18 | to | J216-12 |
| J216-12 | to | J216-1 |

2.1.4 Add a wire between J205, pin 7 and J206, pin 15.

2.1.5 Purpose - To modify the counter in the pulse standardization circuit.

Modification - Add a wire from J205-4 to J206-15.

2.2 Card Modifications

2.2.1 Pulse Standardization

Purpose - To modify counter in Pulse Standardizer circuitry so that a reset is initiated after counting forty-three 200 KHZ pulses instead of eight hundred sixty 200 KHZ pulses as presently required.

Modification - Card J204 - Remove wire from pin P to CR5; add wire from CR5 to pin J.

Card J205 - Remove wires from pin P to CR5, CR12 to pin C, and CR26 to pin 12. Add wires between CR5 (cathode) and pin J, cathodes of CR12 and CR26 to pin 13.

Isolate pin 2 from circuitry.

Isolate pin H from circuitry.

Add a wire between TP2 and pin 2.

Card J206 - This will be a blank jumper card.

Add wires between pin B and pin H, and between pin 15 and pin 7.

Card J208 - Remove C5 (.01 ufd). Replace C5 with .0022 ufd.

2.2.2 Meteorological Data Envelope Detector - J209

Purpose - Reduce the integrator time constant from 350 usec to 17.5 usec. Reduce the pulse width of the one-shot delay generator from 2.0 seconds to 0.10 seconds.

Modification - Replace C10 (2.7 ufd) with 0.135 ufd. Replace C4 (50 ufd) with 2.5 ufd.

2.2.3 Missing Channel Detector - J210

Purpose - Reduce integrator time constant by a factor of 20. Reduce period of delay generator to .3 seconds.

Modification - Replace C5 (3.3 ufd) with 0.165 ufd. Replace C5 (20 ufd) with 2.2 ufd.

2.2.4 Digital Reference Detector

Purpose - To increase the counting rate from 50 HZ to 1000 HZ. This will be accomplished by utilizing the 25 KHZ output on J203, adding a five-stage counter, and utilizing a spare one-shot on J208. The new counter will be preset to a count of seven and after twenty-five additional counts will trigger the one-shot which will serve as the input to the Digital Reference Detector and as the reset signal to the new counter.

Modification - Add Binary Counter cards, Sonex type J2106-D (Drawing No. 2217) in slots J216 and J217. No modifications are required on these cards.

Card J208 - Remove C11 (.01 ufd). Replace C11 with .0025 ufd.

Card J222 - Remove CR10 from pin 7. Add wire from CR10 to pin N.

2.2.5 Fall-out Detector During Reference Gage, J211

Purpose - To reduce the time constants in the integrator circuit by a factor of twenty. Reduce the period of the time delay generator from 1.0 second to 50 milliseconds.

Modification - Replace C2 (0.68 ufd) with .033 ufd. Replace C4 (20 ufd) with 1 ufd.

2.2.6 Reference Detector, Storage and Regeneration

Purpose - Modify ECD Reference Counter to generate a reset after accepting 1000 pulses. Change the counting frequency from 12.5 KHZ to 50 KHZ. Reduce time delay of one-shot J222-F from 1.5 seconds to 60 milliseconds.

Modification - Card J226 - Replace with jumper card with pin B and pin 2 connected.

Card J203 - Isolate pin 2. Connect pin 2 to TP2.

Card J222 - Replace C7 (20 ufd) with 1.0 ufd capacitor.

2.2.7 Temperature, Humidity, and X-Channel Counters

Purpose - The tens, hundreds, and thousands positions of the counters are now being sampled by the output circuits and the data is punched on paper tape. The modification will provide sampling of the units, tens, and hundreds positions of the counters.

Modification - Card J215 - Replace with jumper card with pin B and pin 2 connected.

2.2.8 Modification to Timing for Punch Rate

Purpose - Maximum punch rate is now once every 6 seconds. The new punch rate must be once per second.

Card J102 must be modified to divide by 2 and Cards J103 and J105 must be modified to divide by 25.

Modification - J102 - Isolate pin H. Add a wire between pin H and pin F.

J103 - Remove CR12 from pin C. Add jumper from CR12 to pin P.

J105 - Remove CR5 from pin P. Add jumper from pin 12 to cathode of CR5. Isolate pins N and 14 from circuitry. Add jumpers between pins N and F and pins 14 and 6.

2.2.9 Integrating Amplifiers - J219

Purpose - To change the time constants of the integrating amplifiers.

Modification - Remove C4 (.33 ufd); replace with .015 ufd.

Remove C5 (.01 ufd); replace with .510 pf.

2.2.10 Programming Connector

Purpose - To provide substitute Program Connectors P93 and P193 so that the programming of the MIP will be compatible with the low level radiosonde.

Modification - See Tables I and II for wiring information of P93 and P193.

## TABLE I. WIRING FOR P93 IN GROUPS

| | | | | | |
|---|---|---|---|---|---|
| I. | 7-13 | 1-17 | V. | 11-49 | 35-54 |
| | 13-14 | 2-18 | | 49-50 | 55-45 |
| | 14-15 | 3-78 | | 50-51 | 46-56 |
| | 15-21 | 5-25 | | 51-52 | 47-57 |
| | 21-[illegible] | 76-26 | | 52-53 | 48-58 |
| II. | 8-23 | 17-27 | VI. | 12-28 | 54-62 |
| | 23-66 | 72-78 | | 28-59 | 55-63 |
| | 66-67 | 4-71 | | 59-60 | 56-64 |
| | 67-73 | 25-70 | | 60-74 | 57-65 |
| III. | 29-30 | 35-27 | | | |
| | 30-31 | 36-18 | | | |
| | 31-32 | 37-72 | | | |
| | 32-33 | 38-71 | | | |
| | 33-34 | 39-70 | | | |
| | 34-77 | 40-26 | | | |
| IV. | 10-41 | 36-45 | | | |
| | 41-42 | 37-46 | | | |
| | 42-43 | 38-47 | | | |
| | 43-44 | 39-48 | | | |

Table 2. Wiring for P193

| | |
|---|---|
| Wire 70 tc 74 | Spare Channel in Block No. 3 |
| 77 to 73 | Humidity Channel in Block No. 1 |
| 76 to 71 | Temperature Channel in Block No. 2 |
| Wire 14 to 4 | Space after Humidity |
| 13 to 7 | Space after Humidity |
| Wire 15 to 8 | Space after Temperature |
| 16 to 2 | Space after Temperature |
| Wire 39 to 15 | Space after Spare Channel |
| 38 to 34 | Space after Spare Channel |
| Wire 17 to 10 | Space after Range |
| 18 to 1 | Space after Range |
| Wire 20 to 17 | Space after Elevation |
| 36 to 38 | Space after Elevation |
| Wire 22 to 11 | Space after Hz |
| 21 to 36 | Space after Hz |
| Wire 25 to 12 | Carriage Return |
| 26 to 5 | Carriage Return |
| Wire 23 to 25 | C/R |
| 24 to 21 | C/R |
| Wire 27 to 37 | L/F |
| 28 to 18 | L/F |
| Wire 32 to 27 | Seq. Stop Gate |
| 33 to 28 | Seq. Stop Gate |

## VOLTAGE CONTROLLED OSCILLATOR

The requirements for the Voltage Controlled Oscillator in the Low Level Sounding System are to oscillate over a frequency range of zero to 20 KHZ with an input voltage range of zero to +10 volts, and to provide a positive-going output signal. Since the VCO presently used has a maximum operating frequency of 10 KHZ, it is necessary to replace it with an oscillator which conforms to the new specification.

The Vidar VCO, Model 211-07, which has a frequency range of zero to 50 KHZ was selected as the replacement unit. The negative output of the Model 211-07 is converted to a positive pulse by a single-transistor level changing circuit. The frequency range is changed to zero to 25 KHZ by the addition of a flip-flop which is driven by the level changer. The frequency range is adjusted to zero to 20 KHZ by increasing the value of one of the operational amplifier summing resistors.

Complete information on the modification of the VCO card is given in The Bendix Corporation's Environmental Science Division drawing number 2410494.

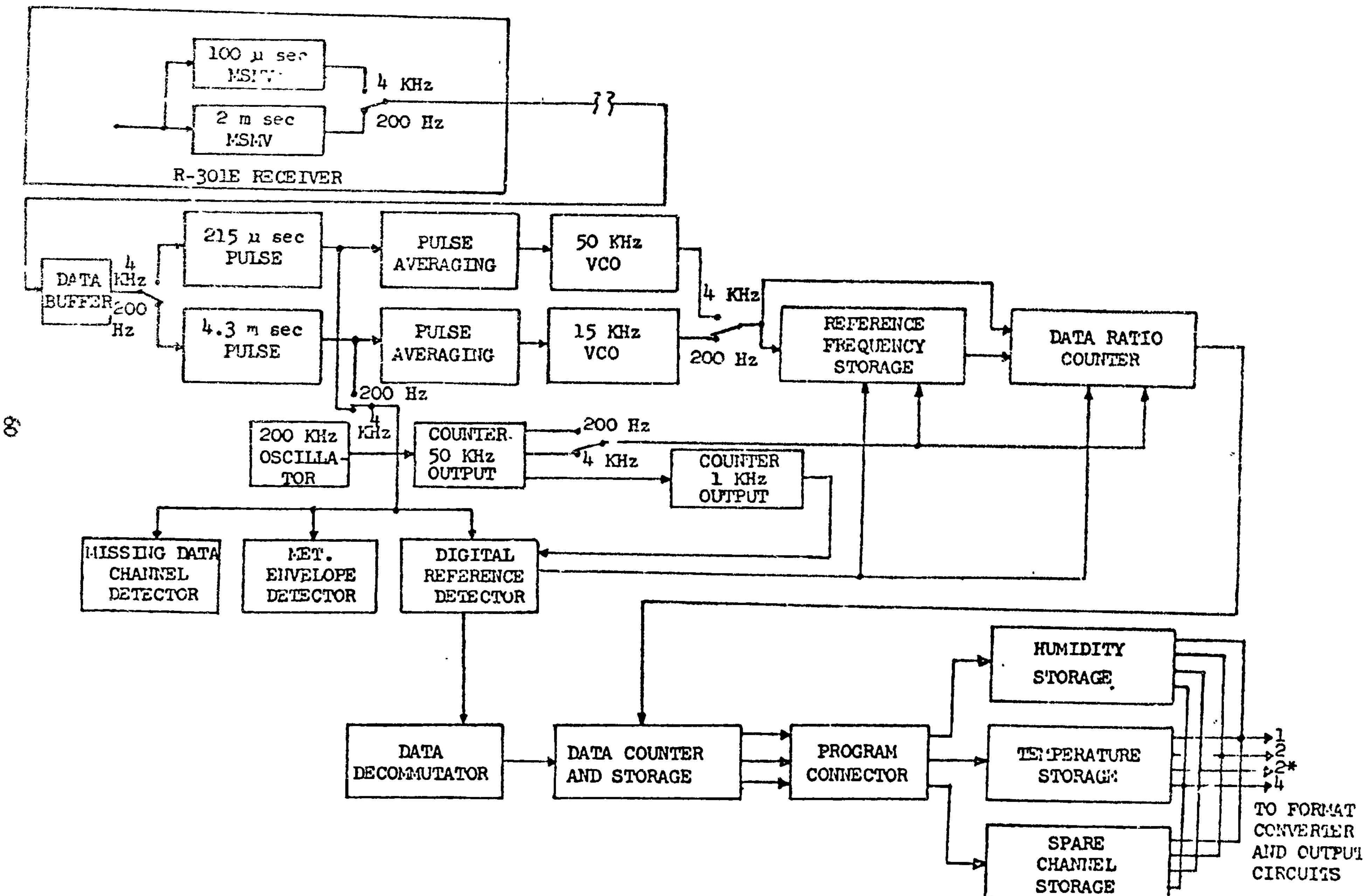



FIGURE 29

AN/GMD-4 MODIFICATION BLOCK DIAGRAM

## F. CRICKET ROCKET

### 1. General

The Cricket Rocket (Cold Rocket Instrument Carrying Kit) is an economical aerial reconnaissance unit designed to aid in the study of the lower atmosphere. The system was designed and manufactured by Texaco Experimental Incorporated of Richmond, Virginia.

The system was designed to carry a payload to a predetermined altitude and then to safely return the vehicle, by means of a parachute, to earth. The two major parts of the system are the rocket and the launcher.

One of the most important features of this system is that the propellant produces no flame and therefore no heat. In addition, the propellant requires no special handling techniques, and has an indefinite storage life and is commercially available at low cost.

The rocket consists of a payload section (low level radiosonde), a recovery section and motor section.

## G. FLIGHT TEST RESULTS

1. The participants during the flight tests of the Low Level Sounding System at the Air Force Eastern Test Range, Cape Kennedy, Florida, the week of June 5, 1967, were as follows:

| | |
|---|---|
| Captain T. Smith | CREU-AFCRL |
| Mr. R. Betz | Bendix ESD |
| Mr. J. Wills | Bendix ESD |
| Mr. R. Ramirez | Bendix ESD |
| Mr. D. Nolte | Texaco Experimental Inc. |
| Mr. J. Davis | Pan Am |
| Mr. R. Stickland | Pan Am |
| Mr. O. Daniels | Pan Am |

Analysis of these flight test results indicated two major problem areas. One of these was attributed to an incompatibility between the RCA S-190 transmitter and the GMD-2 receiver. The automatic frequency control mode of operation of the GMD-2 receiver was not capable of being used because of its bandwidth and slow response time characteristic. It seemed apparent that the S-190 transmitter frequency drift was greater than 450 KC either side of the carrier

frequency, causing the AFC of the GMD-2 receiver to lose frequency lock and drift to its upper frequency limit. As a result of this condition, it was necessary to manually tune the GMD receiver to maintain frequency lock throughout the radiosonde flights.

A mechanical problem was encountered with the rocketsonde version. The original design of the radiosonde (rocket version) required the nose cone to physically drop from the radiosonde unit at approximately T + 15 seconds (apogee) with only gravitational forces providing the separation. This approach was not feasible because of the lack of uniformity of nose cone and radiosonde case dimensions. In conjunction with the above approach, a field replaceable S-190 transmitter quick disconnect and connect antenna was provided. This was necessary due to the drop-off nose cone design for the recoverable and reusable radiosonde design philosophy, whereby the transmitter antenna received damage on impact with the surface.

Captain T. Smith and Bendix personnel agreed to those areas requiring additional investigation before further flight testing.

The flight test data accumulated was reduced and documented by Captain G. Canning, CRER-AFCRL and is presented in tabulated form in the following:

Low Level Sonde System Flight Tests

June 7-9, 1967

Balloonsondes - 4 Flights (Summary)

| | |
|---|---|
| Average time before acquiring good meteorological data | .75 seconds |
| Average time before acquiring good range and angle information | 39.75 seconds |

Number of sets of unusable met data vs. number of sets of data considered starting when usable met data acquired:

| | | | |
|---|---|---|---|
| At approximately T + 5 minutes (#11, 10, 5 and 7) | 34/1108 | = | 3.069% |
| At approximately T + 10 minutes (#11, 10 and 7) | 21/1799 | = | 1.167% |
| At termination at approximately T + 11 minutes (#11, 10 and 7) | 22/1986 | = | 1.108% |

Number of sets of unusable met data vs. number of sets of data considered starting when first usable range data acquired:

| | | | |
|---|---|---|---|
| At approximately T + 5 minutes (#11, 10, 5 and 7) | 8/952 | = | 0.840% |
| At approximately T + 10 minutes (#11, 10 and 7) | 0/1669 | = | 0.0% |
| At termination at approximately T + 11 minutes (#11, 10 and 7) | 0/1856 | = | 0.0% |

Average of maximum variation of spare channel ratio:

| | |
|---|---|
| Not including questionable data acquired = | .00375 |
| Including questionable data acquired = | .00525 |

| | |
|---|---|
| Number of data jumps in fine ranging $\geq$ 20 yards/second vs. number of sets of data considered | 49/1846 = 2.654% |
| Average of maximum data jumps in fine ranging | 35.5 yards/second |
| Maximum questionable changes in temperature data ratio | .005 |
| Maximum questionable changes in humidity data ratio | .060, .031 and .026 |

The above summarized data was obtained from the following test data of individual radiosondes:

<u>Balloonsonde Serial #11</u>

<u>Met Data</u>

| | |
|---|---|
| Time before acquiring usable met data | T + 0 seconds |
| Sonde transmission termination time | T + 10.1 minutes |

Number of sets with unusable met data vs. number of sets of met data considered at:

| | | | | |
|---|---|---|---|---|
| T + 5 minutes | - | 1/300 | = | .333% |
| T + 10 minutes | - | 1/600 | = | .167% |
| Termination | - | 2/609 | = | .328% |

Number of sets with unusable met data vs. number of sets considered starting when usable range data acquired:

| | | | | |
|---|---|---|---|---|
| T + 5 minutes | - | 0/265 | = | .0% |
| T + 10 minutes | - | 0/565 | = | .0% |
| Termination | - | 1/574 | = | 0.17% |

| | |
|---|---|
| Largest questionable data jump in temperature ratio - | 702 to 697 = 5 |

| | |
|---|---|
| Largest questionable data jump in humidity ratio - | 206 to 266 = (60) |
| High spare channel ratio | 504 |
| Low spare channel ratio | 497 |

Ranging Data

Time elapsed before usable fine ranging signal = T + 35 seconds.

Data jumps in fine ranging $\geq$ 20 yards after T + 35 seconds = 5 in 572 printouts.

Maximum data jump in fine ranging after T + 35 seconds = 31 yards (680 - 711).

Course range data jumps 000 to 104 after 1 - 2 seconds.

Course range data accumulated correctly but off by 104 K yards from T + 2 seconds on. Maximum course range change occurred at T + 33 to T + 34 seconds. 207 to 266

| | |
|---|---|
| Angle data jumps | None |

Balloonsonde Serial #10

Met Data

| | |
|---|---|
| Time before acquiring good met data | T + 1 second |
| Sonde transmission termination time | T + 11 minutes |

Number of sets with unusable met data vs. number of sets of met data considered at:

| | | | | |
|---|---|---|---|---|
| T + 5 minutes | - | 1/299 | = | .33% |
| T + 10 minutes | - | 1/599 | = | .17% |
| T + 10.99 minutes | - | 1/659 | = | .15% |

Number of sets with unusable met data vs. number of sets considered starting when usable range data acquired.

| | | | | |
|---|---|---|---|---|
| T + 5 minutes | - | 0/271 | = | .0% |
| T + 10 minutes | - | 0/571 | = | .0% |
| Termination | - | 0/631 | = | .0% |

There were no questionable data jumps in temperature or humidity.

| | |
|---|---|
| Spare channel printout range | 501 to 504 |

Ranging Data

Time elapsed before usable ranging data = T + 29 seconds.

Maximum fine range jumps after T + 29 seconds = 30 yards/second.

Number of data jumps $\geq$ 20 yards after T + 29 seconds = 7/630 = 1.11%.

Course ranging data jumps:

| | | |
|---|---|---|
| 000 | 102 | at T + 29 - 30 seconds |
| 103 | 106 | at T + 402 - 403 seconds |

Coarse ranging usable data after T + 403 seconds.

After T + 659 seconds, no temperature or spare channel data received.

Humidity data still constant.

Ranging data jumps in 35 to 40 yard increments.

Azimuth angle jumps 180° to 193° at T + 10 - 11 seconds.

Balloonsonde Serial #5

Met Data

| | |
|---|---|
| Time elapsed before acquiring good data | T + 2 seconds |
| Sonde data transmission termination | T + 672 seconds |

No met data received after T + 210 seconds.

Number of sets with unusable met data vs. number of sets of met data considered at:

| | |
|---|---|
| T + 2 to T + 210 seconds | 13/209 = 6.22% |
| T + 28 to T + 210 seconds | 8/183 = 4.37% |

Erratic data jumps in temperature data were obviously bad.

Maximum data jumps in humidity printout — 536 to 505 = 31

Ranging Data

Maximum data jumps in ranging data after T + 28 seconds:

2858 to 2914 yards = 56 yards

| | |
|---|---|
| Maximum data jumps $\geq$ 20 yards occurring between T + 26 to T + 671 seconds | 37/643 = 5.75% |
| Low-High spare channel printouts | 499 - 503 |

| | |
|---|---|
| Maximum Azimuth Angle data jumps | 188.4° to 197.85° |
| Maximum Elevation Angle data jumps | 12.67° to 19.33° |

Even though met data appeared to be good at T + 2 seconds, the data jumps in angle information indicated that the GMD unit was not on target. This might explain some of the unusable data accumulated at T + 17, 18, 24, 25 and 26 seconds. Using this assumption, the GMD receiver was then manually tuned for the remainder of the flights and the AFC problem with the system was diagnosed.

Course ranging data jump from 003 to 006 occurred at T + 577 and T + 578 seconds.

At T + 327 seconds, no range, angle, or time printouts occurred.

At T + 335 seconds, printout started with range, angle and time of T + 327.

Next good range, angle, and time printout occurred at T + 336 seconds.

Balloonsonde Serial #7

Met Data

| | |
|---|---|
| Time elapsed before acquiring good data | T + 0 seconds |
| Sonde data transmission termination | T + 718 seconds |

Number of sets with unusable met data vs. number of sets of met data considered at:

| | |
|---|---|
| T + 5 minutes | 19/300 = 6.33% |
| T + 10 minutes | 19/600 = 3.17% |
| T + 11.95 minutes | 19/718 = 2.65% |

Number of sets with unusable met data vs. number of sets considered starting when usable range data acquired:

| | |
|---|---|
| T + 5 minutes | 0/233 = 0% |
| T + 10 minutes | 0/533 = 0% |
| T + 11.95 minutes | 0/151 = 0% |

Maximum data jump in temperature ratio printouts--data jumps occurring were obviously bad.

| | |
|---|---|
| Maximum data jump in humidity ratio printout | 402 - 428 |
| Low-High spare channel ratio printouts | 500 - 504 |

Ranging Data

Elapsed time before usable ranging data acquired = T + 67 seconds.

Data jumps in fine ranging $\geq$ 20 yards after T + 67 seconds 3/650 = .46%

Maximum data jumps in fine ranging occurred between T + 167 and T + 168 seconds:

1201 - 1226 = 25 yards

At beginning of flight, in coarse range printout were 4 sets of numbers reading 999(9--) from T + 5 to T + 8 seconds.

Operation of the system indicates switching between coarse range and fine range can cause an internal error in the GMD readout as evidenced from the flight test data recorded. When going from 999997 to 000078 the latter reading was indeterminate.

After T + 67 seconds, coarse ranging data was usable.

Maximum angle data jumps in elevation $9.44^\circ$ to $18.71^\circ = 9.27^\circ$

Maximum angle data jumps in azimuth $163.47^\circ$ to $173.4^\circ = 9.93^\circ$

Printout data for this balloonsonde indicated that release occurred at T + 46 seconds although ranging data began accumulating at T + 0 seconds.

Rocketsondes (Summary of 2 Flights Considered)

Sondes, serial numbers 1 and 12, were considered out of 3 flights conducted. The third sonde provided no usable data. It was during the third test flight, that the original design drop-off nose cone became detached from the unit on ascent. Hopes of recovering the unit to determine cause were shattered when the unit landed in the ocean about 200 yards offshore. After discussion between Captain Smith and Bendix personnel, it was assumed that cause of failure be attributed to bending over of the RCA S-190 transmitting antenna and destruction of the sensors when the nose cone was ripped from the unit on ascent. None of the three rocketsondes flight-tested provided usable ranging information. The same parties investigated this problem at the site as a low signal level, coupled with the AFC problem previously mentioned. Both of these were to be investigated further by Bendix.

| | |
|---|---|
| Average elapsed time before acquiring usable met data | T + 54 seconds |
| Average sonde transmitting termination time | T + 273.5 seconds |

Number of sets of unusable met data vs. number of sets of met data considered starting with first usable data acquired:

15/438 = 3.424%

| | |
|---|---|
| Average maximum variation of spare channel ratio | 0.00250 |

Ranging Data

No usable ranging data accumulated.

Average maximum elevation angle of 15.44° at an average time of T + 14.5 seconds.

The above summarized data was obtained from the following test data of individual rocketsondes:

Rocketsonde Serial #1

Met Data

Time before acquiring usable met data T + 33 seconds

Sonde transmitting termination time T + 275 seconds

Number of sets of unusable met data vs. number of sets of met data considered starting with first usable data acquired:

$$14/242 = 5.79\%$$

Low-High spare channel ratio printout 504 - 506

Temperature and humidity data jumps observed were obviously in error.

Ranging Data

No usable ranging data acquired.

Fine range data changed only a maximum of 18 yards in 54 seconds.

Coarse range data was very erratic.

Maximum elevation angle recorded was 15.23° at T + 15 seconds.

Rocketsonde Serial #12

Met Data

Time before acquiring usable met data T + 75 seconds

Sonde transmission termination time T + 272 seconds

There were no questionable data jumps in the temperature or humidity data acquired.

| | |
|---|---|
| Low-High spare channel ratio printout | 504 - 507 |

Number of sets with unusable met data vs. number of sets of data considered from first usable data acquired:

1/196 = .51%

Ranging Data

The system did not function properly in either coarse or fine ranging modes. The weak ranging signal being transmitted from the sonde was the apparent problem here.

Maximum elevation angle recorded was 15.64° at T + 14 seconds.

2. The participants of the second flight tests conducted at Cape Kennedy, Florida during the week of October 8, 1967 were:

| | |
|---|---|
| Captain T. Smith | CREU-AFCRL |
| Mr. R. Betz | Bendix ESD |
| Mr. J. Wills | Bendix ESD |
| Mr. D. Nolte | Texaco Experimental Inc. |
| Mr. R. Ramirez | Bendix ESD |
| Mr. J. Davis | Pan Am |
| Mr. R. Stickland | Pan Am |
| Mr. O. Daniels | Pan Am |

After investigating those problem areas evidenced during the first flight tests conducted, Bendix made redesign changes to the nose cone, the RCA S-190 transmitter antenna and input circuitry, and the balloon case design. Bendix and the U. S. Air Force personnel then returned to the Air Force Eastern Test Range to conduct further tests. The results of these tests are as follows:

Low Level Sonde System Flight Tests

October 9-11, 1967

Balloonsondes - 7 Flights (Summary)

| | |
|---|---|
| Average time before acquiring usable met data | T + 27.14 seconds |
| Average time before acquiring usable ranging data | T + 21.00 seconds |

Number of sets of unusable met data vs. number of sets of met data considered after first usable met data acquired:

| | | | |
|---|---|---|---|
| T + 5 minutes | 139/1827 | = | 7.61% |
| T + 10 minutes | 294/3835 | = | 7.67% |
| Termination (4 Flights) | 296/2516 | = | 11.76% |

Number of sets of unusable met data vs. number of sets of data considered after first usable ranging data acquired at:

| | | | |
|---|---|---|---|
| T + 5 minutes (4 Flights) | 73/811 | = | 9.00% |
| T + 10 minutes (3 Flights) | 178/1711 | = | 10.40% |
| Termination (2 Flights) | 171/1229 | = | 13.91% |

Average of maximum variation in spare channel ratio:

| | |
|---|---|
| With only usable data | .00400 |
| Including questionable data | .00671 |

Number of data jumps in fine ranging $\geq$ 20 yards/second vs. number of sets of data considered: (6 Flights)

308/3597 = 8.56%

Average of maximum data jumps in fine ranging:

39.9 yards/second

<u>Rocketsondes - 5 Flights (Summary)</u>

| | |
|---|---|
| Average time before acquiring usable met data | T + 12 seconds (4 Flights) |
| Average time before acquiring usable ranging data | T + 2 seconds |

Number of unusable data sets vs. number of data sets considered from beginning of usable data:

152/1069 = 14.22% (4 Flights)

Sonde transmission termination time T + 276.2 seconds

Average maximum variation of spare channel with:

| | |
|---|---|
| Usable data only | .0040 (3 flights) |
| Questionable data included | .00725 (4 flights) |

Number of data jumps in fine ranging ≥ 20 yards/second vs. number of data sets considered:

18/1296 = 1.39% (5 flights)

| | |
|---|---|
| Average of maximum data jumps in fine ranging | 37.0 yards (4 flights) |
| Average of maximum elevation angles | 17.88° at average time of 15 seconds |
| Average of payload apogee times @ maximum elevation angle occurrence | T + 14.9 seconds |

The above balloonsonde flight test summaries were derived from the following individual sonde flights:

Balloonsonde Serial #18

Met Data

| | |
|---|---|
| Good met data at | T + 26 seconds |
| Good range and angle data at | T + 53 seconds |
| Sonde termination time | T + 674 seconds |

Unusable met data vs. number of data sets considered starting when good met data acquired:

| | | | |
|---|---|---|---|
| T + 5 minutes | - 14/274 | = | 5.11% |
| T + 10 minutes | - 15/574 | = | 2.61% |
| T + 11.2 minutes | - 16/648 | = | 2.47% |

Unusable met data vs. number of data sets considered starting when good ranging data acquired:

| | | | |
|---|---|---|---|
| T + 5 minutes | - 9/247 | = | 3.64% |
| T + 10 minutes | - 10/547 | = | 1.83% |
| T + 11.2 minutes | - 11/621 | = | 1.77% |

Low-High spare channel printout 498 - 503

Maximum temperature data jumps at T + 469 - T + 470 = .010.

Maximum humidity data jumps at T + 53 - T + 54 = .020.

Ranging Data

Ranging data jumps ≥ 20 yards/second after T + 52 seconds:

91/620 = 14.68%

Maximum ranging data jump 52 yards

Coarse ranging good between T + 53 and T + 316 seconds.

Coarse ranging not usable after T + 316 seconds.

Maximum angle data jumps: Elevation 8.53°

Azimuth 10.22°

Balloonsonde Serial #13

Met Data

Good met data at T + 29 seconds (temperature and humidity at T + 15).

| | |
|---|---|
| Good range and angle data | T + 17 seconds |
| Termination time: Met data | T + 528 seconds |
| Range data | T + 572 seconds |

Unusable met data vs. number of data sets considered at:

| | |
|---|---|
| T + 5 minutes | 40/271 = 14.76% |
| Termination | 42/499 = 8.42% |

| | |
|---|---|
| Low-High spare channel | 496 - 503 |
| Temperature data jumps | None |

Humidity data jump from T + 115 to T + 117 = .026.

Ranging Data

Data jumps in fine range $\geq$ 20 yards/second after T + 17 seconds:

59/554 = 10.65%

| | |
|---|---|
| Maximum data jump in fine range | 37 yards |
| Maximum data jump in coarse range | None |

No significant angle data jumps.

Many channel shifts occurred in data printout. Majority of these were spare channel to temperature and temperature to humidity.

Balloonsonde Serial #6

Met Data

| | |
|---|---|
| Good met data at | T + 21 seconds |
| Good ranging and angle at | T + 23 seconds |
| Termination time | T + 631 seconds |

Unusable met data vs. number of data sets considered at:

| | |
|---|---|
| T + 5 minutes | 64/279 = 22.94% |
| T + 10 minutes | 160/579 = 27.63% |
| Termination | 160/610 = 26.23% |

| | |
|---|---|
| Low-High spare channel | 491 - 508 |

Maximum temperature data jump at T + 713 - 714 = 014.

Maximum humidity data jump at T + 351 - 352 = 014.

Ranging Data

Data jumps in range $\geq$ 20 yards/second after T + 23 seconds:

102/607 = 16.8%

Maximum range data jump at T + 402 - 403 = 54 yards.

No usable coarse range data acquired.

Erroneous number value of 599 printed out in spare channel four successive printouts while remaining channels exhibited good usable data.

Balloonsonde Serial #9

Met Data

| | |
|---|---|
| Good met data at | T + 7 seconds |
| Good range data at | T + 13 seconds |
| Termination time | T + 2444 seconds (40.7 minutes) |

This sonde was released without setting the 10 minute timer so as to obtain data in excess of the design requirement. The GMD data processor was also set to provide interval printouts. Unusual

breaks in data translation occurred during this flight which can be traced to either loss of high reference, or the met data processor subsystem.

Unusable met data vs. number of data sets considered at:

| | |
|---|---|
| T + 5 minutes | 0/293 = 0% |
| T + 10 minutes | 8/593 = 1.35% |

| | |
|---|---|
| Low-High spare channel printout | 500 - 503 |
| Temperature data jumps | None |
| Humidity data jumps | None |

Ranging Data

Data jumps in ranging $\geq$ 20 yards/second not meaningful with the large number of breaks in data.
Maximum data jump in ranging at T + 546 to T + 547 seconds = 40 yards.

| | |
|---|---|
| Number of angle data jumps | None |

## Balloonsonde Serial #14

Met Data

| | |
|---|---|
| Good met data at | T + 47 seconds |
| Good range data at | T + 18 seconds |
| Termination time at | T + 580 seconds |

Unusable met data vs. number of data sets considered at:

| | |
|---|---|
| T + 5 minutes | 2/253 = .79% |
| Termination | 2/533 = .38% |

| | |
|---|---|
| Low-High spare channel printout | 502 - 504 |

Ranging Data

Data jumps in range $\geq$ 20 yards/second after T + 18 seconds:

30/561 = 5.35%

Maximum data jump in range at T + 192 - 193 seconds = 32 yards.

Coarse range data satisfactory except for printouts between T + 6 to T + 15 seconds at 9999(--).

| | |
|---|---|
| Number of angle data jumps | None |

Balloonsonde Serial #8

Met Data

| | |
|---|---|
| Good met data at | T + 26 seconds |
| Good range data at | T + 11 seconds |
| Termination time | T + 618 seconds |

Unusable met data vs. number of data sets considered at:

| | |
|---|---|
| T + 5 minutes | 5/191 = 2.62% |
| T + 10 minutes | 19/491 = 3.87% |
| Termination | 19/509 = 3.73% |

No data received from T + 213 to T + 295 seconds.

| | |
|---|---|
| Low-High spare channel printouts | 495 - 500 |
| Number of temperature data jumps | None |

Humidity data jumps at:

| | |
|---|---|
| T + 308 to T + 309 seconds | 101 |
| T + 309 to T + 310 seconds | 041 |

Ranging Data

Number of range data jumps $\geq$ 20 yards/second after T + 11 seconds:

12/606 = 1.98%

Maximum range data jump at T + 493 - 494 = 37 yards.

Coarse range data satisfactory except for times T + 2 through T + 9 seconds.

Number of significant angle data jumps None

A considerable number of zero data sets were evident on printout--appear to be extra-high reference pulses.

Balloonsonde Serial #17

Met Data

| | |
|---|---|
| Good met data at | T + 34 seconds |
| Good range data at | T + 12 seconds |

| | | |
|---|---|---|
| Termination time | | T + 783 seconds |

Unusable met data vs. number of data sets considered at:

| | |
|---|---|
| T + 5 minutes | 14/266 = 5.26% |
| T + 10 minutes | 48/566 = 8.48% |
| Termination | 101/749 = 13.48% |

| | |
|---|---|
| Low-High spare channel printout | 502 - 506 |
| Number of temperature data jumps | None |

Humidity data jumps at:

| | |
|---|---|
| T + 210 - T + 211 seconds | 035 |
| T + 211 - T + 212 seconds | 023 |
| T + 212 - T + 213 seconds | 051 |

Ranging Data

Number of range data jumps $\geq$ 20 yards/second after T + 12 seconds:

14/770 = 1.82%

Maximum range data jump at T + 203 - 204 seconds = 27 yards.

Coarse range data satisfactory.

Number of angle data jumps None

The following individual rocketsonde data was used to compile the rocketsonde summary sheet found at the beginning of this flight test sequence:

Rocketsonde Serial #19

Met Data

No usable met data received.

Ranging data satisfactory from T + 1 second except at:

T + 1 to T + 2 data jump of 66

T + 2 to T + 3 data jump of 75

Termination time T + 264 seconds

Ranging Data

Number of range data jumps $\geq$ 20 yards/second considered from T + 15 seconds:

6/248 = 2.42%

Coarse range data satisfactory.

| | |
|---|---|
| Number of angle data jumps | None |
| Maximum elevation angle | $16.07^{\circ}$ at T + 14 seconds |

Rocketsonde Serial #3

Met Data

| | |
|---|---|
| Good met data at | T + 28 seconds |
| Good range data at | T + 3 seconds |
| Termination time | T + 274 seconds |

Unusable met data vs. number of data sets considered at termination:

23/246 = 9.35%

Low-High spare channel printout 498 - 505

Maximum temperature data jump at T + 197 - 198 = 013.

Maximum humidity data jump at T + 114 - 115 = 037.

Ranging Data

Number of range data jumps $\geq$ 20 yards/second after T + 16 seconds:

None

Coarse range data satisfactory.

Azimuth angle data jumps at:

| | |
|---|---|
| T + 258 | 104.55 degrees |
| T + 259 | 103.96 degrees |
| T + 260 | 104.55 degrees |
| T + 261 | 105.83 degrees |
| T + 262 | 104.29 degrees |
| T + 263 | 103.12 degrees |
| T + 264 | 103.[illegible]8 degrees |

Maximum elevation angle of $17.33^{\circ}$ at T + 15 seconds.

A considerable number of met data printout errors were in the 900 digits.

Rocketsonde Serial #4

Met Data

| | |
|---|---|
| Good met data at | T + 3 seconds |
| Good range data at | T + 4 seconds |
| Termination time | T + 278 seconds |

Unusable data sets vs. number of data sets considered at termination:

49/275 = 17.82%

| | |
|---|---|
| Low-High spare channel printout | 501 - 504 |
| Temperature data jumps at: | |
| T + 198 - 199 seconds | 012 |
| T + 200 - 201 seconds | -012 |
| Humidity data jumps at: | |
| T + 165 - 166 seconds | -030 |
| T + 166 - 167 seconds | +030 |

Ranging Data

Number of range data jumps $\geq$ 20 yards/second after T + 16 seconds:

2/262 = .76%

Maximum range data jumps at T + 258 - 259 = 31 yards.

| | |
|---|---|
| Number of angle data jumps | None |

Coarse range data satisfactory.

| | |
|---|---|
| Maximum elevation angle | $17.92^{\circ}$ at T + 15 seconds |

Rocketsonde Serial #15

Met Data

| | |
|---|---|
| Good met data at | T + 14 seconds |

| | |
|---|---|
| Good range data at | T + 3 seconds |
| Termination time | T + 291 seconds |

Unusable met data vs. number of data sets considered at termination:

17/277 = 6.14%

| | |
|---|---|
| Low-High spare channel printout | 505 - 507 |
| Number of temperature data jumps | None |

Humidity data jumps at:

| | |
|---|---|
| T + 122 - 123 seconds | -060 |
| T + 123 - 124 seconds | -064 |
| T + 124 - 125 seconds | -028 |

Ranging Data

Number of range data jumps $\geq$ 20 yards/second after T + 17 seconds:

3/274 = 1.09%

Maximum range data jump at T + 242 - 243 seconds = 24.

Coarse range data satisfactory.

| | |
|---|---|
| Number of angle data jumps | None |

Maximum elevation angle of 18.77° at T + 16 seconds.

Rocketsonde Serial #2

Met Data

| | |
|---|---|
| Good met data at | T + 3 seconds |

Unusable met data from T + 15 through T + 23 seconds.

| | |
|---|---|
| Good range data at | T + 0 second |
| Termination time | T + 274 seconds |

Unusable met data vs. number of data sets considered:

63/271 = 23.25%

| | |
|---|---|
| Low-High spare channel printout | 496 - 513 |

Temperature data jumps at:

| | |
|---|---|
| T + 165 - 166 seconds | -017 |
| T + 166 - 167 seconds | +017 |

Humidity data jump at
T + 147 - 148 seconds 026

Ranging Data

Number of range data jumps $\geq$ 20 yards/second after T + 16 seconds:

8/258 = 3.1%

Coarse range data satisfactory.

Maximum elevation angle of $19.30^{\circ}$ at T + 15 seconds.

One set of unusable data was repeated three times (printout). This again may be caused by extraneous high reference data pulses or just plain noise.

3. Flight tests of the Low Level Sonde System were conducted at AFCRL, Hanscom Field, in May 1968. Participants of this flight test sequence were:

| | |
|---|---|
| Captain T. Smith | CREU-AFCRL |
| Captain G. Canning | CRER-AFCRL |
| Mr. R. Betz | Bendix ESD |
| Mr. J. Wills | Bendix ESD |

Two balloonsonde flights were made, however, the serial numbers of the radiosondes were not recorded. Both flight tests were conducted with separate objectives. The first was made with low temperature coefficient resistor values of 15 K ohms, 112.4 K ohms and 900 K ohms to determine stability of the radiosonde circuitry. The second flight consisted of a balloonsonde configuration with a rocketsonde sensor package attached. The objective here was to make a comparison flight for correlation of temperature data between the two types of sensor mounting packages used. From the data acquired, it appears that the metallic mass associated with the rocketsonde sensor package configuration may be contributing to its slow response time. Subsequently, Bendix ESD provided a nylon shield, to be substituted for the metallic shield originally supplied, to AFCRL for evaluation.

FLIGHT #1 - Balloonsonde with lo-temperature coefficient resistors installed in sensor mounts:

After T + 10 minutes

| Resistor Value | Printout Range | Ord. Variation |
|---|---|---|
| 15 K | 891 - 902 | 11 |
| 112.4 K | 500 - 506 | 6 |
| 900 K | 119 - 122 | 3 |

After T + 45 minutes

| Resistor Value | Printout Range | Ord. Variation |
|---|---|---|
| 15 K | 887 - 902 | 15 |
| 112.4 K | 496 - 506 | 10 |
| 900 K | 115 - 122 | 7 |

FLIGHT #2 - Flight made with both balloonsonde and rocketsonde sensor packages attached with ML-419 sensors installed:

| T + Min. | T + Sec. | Temp. (°C) Balloonsonde Configuration | Temp. (°C) Rocketsonde Configuration | Temperature Diff. (°C) |
|---|---|---|---|---|
| 0 | 0 | +25.5 | +25.5 | +0 |
| .15 | 9 | 12.3 | 14.0 | 1.7 |
| .33 | 20 | 11.4 | 12.2 | .8 |
| .83 | 50 | 10.1 | 10.8 | .7 |
| 1.67 | 100 | 9.3 | 9.9 | .6 |
| 6.50 | 390 | 5.6 | 6.4 | .8 |
| 10.0 | 600 | --- | --- | --- |
| 13.33 | 800 | -3.1 | -2.4 | -.7 |
| 19.53 | 1172 | -17.1 | -16.4 | -.7 |
| 20.0 | 1200 | --- | --- | --- |

In addition to flight testing of the low-level radiosonde, Bendix and AFCRL personnel performed the modification of the GMD data processor which was necessary to make it compatible with the system.

During checkout of the GMD, it was found that the coarse ranging system of the unit was not functioning properly.

One other incident worth mentioning here was that the GMD receiver would not operate in the automatic AFC mode. An on-the-spot analysis indicated the possibility of other equipments in the area operating on the same frequency causing interference.

Upon concluding the flight tests, the GMD unit was returned to normal operation.

4. Final Flight Testing of the Low Level Sounding System was conducted at Vandenberg Air Force Base, California (AFWTR). The participants of this test were:

| | |
|---|---|
| Captain G. Canning | CREU-AFCRL |
| Mr. R. Betz | Bendix ESD |
| Mr. J. Wills | Bendix ESD |

The objective here was to fly one balloonsonde with both sensor packages attached and to launch one rocketsonde. The rocket launch was not achieved due to problems encountered--first, with baselining the sonde and second, a leak developing in the launcher.

Results of this flight test verified the findings of the flight test of May, 1968. After installing an ML-419 temperature sensor in both sensor mounts, the rocket version was found to have a much slower response than the balloon version.

In addition, no usable met data was received until T + 38 seconds, and the spare channel data printout was intermittent.

Sample copies of a GMD data processor--teletype printout, and a computer processed data printout appear in Figures 30 and 31 respectively.

| | | | | | | |
|---|---|---|---|---|---|---|
| 703 | 363 | 493 | 000447 | 2643 | 05637 | 0031 |
| 703 | 369 | 499 | 000454 | 2670 | 05708 | 0032 |
| 703 | 369 | 501 | 000456 | 2693 | 05715 | 0033 |
| 703 | 367 | 501 | 000463 | 2721 | 05717 | 0034 |
| 707 | 367 | 502 | 000475 | 2703 | 05717 | 0035 |
| 707 | 365 | 501 | 000430 | 2732 | 05717 | 0036 |
| 706 | 363 | 501 | 000436 | 2751 | 05717 | 0037 |
| 706 | 364 | 501 | 000496 | 2753 | 05715 | 0033 |
| 706 | 363 | 501 | 000507 | 2774 | 05714 | 0039 |
| 707 | 360 | 502 | 000527 | 2790 | 05723 | 0040 |
| 706 | 360 | 502 | 000533 | 2793 | 05733 | 0041 |
| 706 | 360 | 501 | 000543 | 2793 | 05730 | 0042 |
| 705 | 357 | 502 | 000555 | 2731 | 05725 | 0043 |
| 705 | 353 | 502 | 000567 | 2757 | 05726 | 0044 |
| 705 | 343 | 502 | 000537 | 2755 | 05736 | 0045 |
| 705 | 358 | 501 | 000593 | 2751 | 05736 | 0046 |
| 704 | 347 | 501 | 000593 | 2757 | 05720 | 0047 |
| 705 | 349 | 502 | 000603 | 2772 | 05590 | 0043 |
| 705 | 343 | 502 | 000617 | 2772 | 05664 | 0049 |
| 703 | 341 | 502 | 000629 | 2770 | 05650 | 0050 |
| 703 | 334 | 501 | 000623 | 2765 | 05633 | 0051 |
| 703 | 324 | 501 | 000635 | 2752 | 05616 | 0052 |
| 703 | 322 | 501 | 000652 | 2740 | 05601 | 0053 |
| 703 | 316 | 501 | 000649 | 2706 | 05591 | 0054 |
| 703 | 310 | 501 | 000672 | 2713 | 05586 | 0055 |
| 702 | 306 | 501 | 000675 | 2693 | 05534 | 0056 |
| 701 | 30[illegible] | 502 | 000637 | 26[illegible] | 05583 | 0057 |
| 703 | 300 | 501 | 000703 | 2661 | 05570 | 0053 |
| 702 | 230 | 502 | 000707 | 2647 | 05540 | 0059 |
| 701 | 2[illegible] | 501 | 000717 | 2634 | 05514 | 0060 |
| 700 | 239 | 501 | 000725 | 2623 | 05493 | 0061 |
| 700 | 295 | 501 | 000730 | 2603 | 05433 | 0062 |
| 701 | 300 | 502 | 000741 | 2595 | 05430 | 0063 |
| 700 | 301 | 502 | 000754 | 2585 | 05431 | 0064 |
| 701 | 303 | 501 | 000760 | 2566 | 05431 | 0065 |
| 700 | 304 | 501 | 000770 | 2540 | 05470 | 0066 |
| 700 | 303 | 501 | 000783 | 2523 | 05463 | 0067 |
| 700 | 304 | 501 | 000795 | 2506 | 05461 | 0063 |
| 701 | 304 | 502 | 000803 | 2494 | 05465 | 0069 |
| 701 | 305 | 503 | 000815 | 2474 | 05463 | 0070 |
| 700 | 306 | 501 | 000823 | 2450 | 05453 | 0071 |
| 700 | 303 | 501 | 000837 | 2430 | 05457 | 0072 |
| 701 | 307 | 502 | 000854 | 2420 | 05455 | 0073 |
| 70[illegible] | 303 | 501 | 000856 | 24[illegible]7 | 05453 | 0074 |
| 70[illegible] | 310 | 501 | 000879 | 2339 | 05466 | 0075 |
| 70[illegible] | 310 | 501 | 000339 | 2379 | 05455 | 0076 |
| 701 | 303 | 503 | 000903 | 2362 | 05457 | 0077 |
| 701 | 309 | 501 | 000916 | 2343 | 05456 | 0073 |
| 701 | 310 | 501 | 000930 | 2336 | 05460 | 0079 |

FIGURE 30. GMD Data Processor--Teletype Printout

| ALTITUDE FEET | DIR DEG | SPEED KTS | TEMP DEG C | DEW PT DEG C | PRESS MBS | RH PCT | ABS HUM G/M3 | DENSITY G/M3 | I/C | WS KTS | SHEAR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1050 | 23[illegible] | 23 | 21.0 | 18.3 | 975.87 | 84 | 15.54 | 115[illegible].75 | 34[illegible] | [illegible] | [illegible] |
| 1075 | 233 | 22 | 20.8 | 1[illegible].1 | 975.01 | 86 | 15.34 | 1154.44 | 347 | [illegible] | 2 |
| 1100 | 236 | 22 | 21.0 | 18.3 | 974.14 | 84 | 15.51 | 1152.71 | 347 | [illegible] | 1 |
| 1125 | 235 | 22 | 20.7 | 17.9 | 973.28 | 84 | 15.15 | 1153.25 | 34[illegible] | [illegible] | 1 |
| 1150 | 233 | 22 | 20.8 | 17.9 | 972.42 | 84 | 15.19 | 1151.01 | [illegible] | [illegible] | [illegible] |
| 1175 | 235 | 22 | 20.7 | 17.[illegible] | 971.56 | [illegible] | 15.11 | 115[illegible] | [illegible] | [illegible] | 1 |
| 1200 | 235 | 22 | 20.8 | 17.9 | 970.70 | 83 | 15.15 | 114[illegible].39 | 345 | [illegible] | 1 |
| 1225 | 235 | 24 | 20.9 | 1[illegible].0 | 969.85 | [illegible] | 15.25 | 1147.[illegible] | 345 | [illegible] | 3 |
| 1250 | 233 | 27 | 21.0 | 18.0 | 969.02 | 83 | 15.27 | 114[illegible].77 | 345 | [illegible] | [illegible] |
| 1275 | 232 | 24 | 20.7 | 17.7 | 968.17 | 83 | 14.99 | 1147.28 | 343 | [illegible] | 3 |
| 1300 | 235 | 25 | 20.8 | 17.9 | 967.31 | 83 | 15.15 | 1145.29 | 344 | [illegible] | 2 |
| 1325 | 236 | 22 | 20.7 | 17.6 | 966.46 | [illegible] | [illegible] | 114[illegible].7[illegible] | 342 | [illegible] | [illegible] |
| 1350 | 236 | 23 | 20.7 | 17.5 | 965.60 | 82 | 14.79 | 114[illegible] | 341 | [illegible] | 1 |
| 1375 | 237 | 22 | 20.7 | 17.5 | 964.75 | 82 | 14.77 | 1143.23 | 341 | [illegible] | 1 |
| 1400 | 236 | 21 | 20.7 | 17.4 | 963.89 | 82 | 14.74 | 1142.02 | 341 | [illegible] | 1 |
| 1425 | 23[illegible] | 23 | 20.6 | 17.2 | 963.04 | 81 | 14.54 | 114[illegible].42 | 33[illegible] | [illegible] | 1 |
| 1450 | 23[illegible] | 24 | 20.4 | 17.[illegible] | 962.19 | 81 | 14.39 | 11[illegible].44 | [illegible] | [illegible] | 2 |
| 1475 | 24[illegible] | 2[illegible] | [illegible] | 1[illegible] | [illegible]1.34 | 79 | [illegible] | 11[illegible] | 337 | [illegible] | [illegible] |
| 1500 | 242 | 27 | 20.[illegible] | 16.7 | [illegible].49 | 7[illegible] | 14.11 | 113[illegible].21 | 336 | [illegible] | [illegible] |
| 1525 | 243 | 2[illegible] | 2[illegible] | 1[illegible] | [illegible] | 77 | 13.90 | 1137.50 | 335 | [illegible] | [illegible] |
| 1550 | 240 | 2[illegible] | 20.7 | 16.5 | 95[illegible].79 | 77 | 13.35 | 1136.05 | 334 | [illegible] | 1 |
| 1575 | 245 | 25 | 20.[illegible] | 16.4 | 957.94 | 76 | 13.73 | 1134.47 | 33[illegible] | [illegible] | 2 |
| 1600 | 241 | 27 | 20.5 | 16.1 | 957.10 | 75 | 13.52 | 1134.7[illegible] | 332 | [illegible] | |
| 1625 | 24[illegible] | 2[illegible] | [illegible].7 | 1[illegible] | 956.25 | 7[illegible] | 13.4[illegible] | 113[illegible] | 331 | [illegible] | [illegible] |
| 1650 | 242 | 27 | 20.[illegible] | 16.0 | 955.40 | 74 | 13.47 | 1131.48 | 331 | [illegible] | [illegible] |
| 1675 | 243 | 2[illegible] | 2[illegible] | 15.[illegible] | 954.56 | 74 | 13.34 | 1131.1[illegible] | 33[illegible] | [illegible] | [illegible] |
| 1700 | 240 | 23 | 20.[illegible] | 15.7 | 953.71 | 73 | 13.22 | 1130.20 | 3[illegible] | [illegible] | [illegible] |
| 1725 | 243 | 31 | 2[illegible].7 | 15.[illegible] | 952.87 | 73 | 13.24 | 1129.[illegible] | 32[illegible] | [illegible] | [illegible] |
| 1750 | 245 | 31 | 20.5 | 15.6 | 952.03 | 73 | 13.03 | 112[illegible] | 32 | [illegible] | 1 |
| 1775 | 24[illegible] | 2[illegible] | 2[illegible] | 15.[illegible] | 951.22 | 7[illegible] | 1[illegible] | 112[illegible] | 327 | [illegible]7 | |
| 1800 | 24[illegible] | 2[illegible] | 20.4 | 15.5 | 950.38 | 73 | 13.02 | 1126.[illegible] | 327 | [illegible] | [illegible] |
| 1825 | 242 | 24 | 20.3 | 15.4 | 949.53 | 73 | 12.92 | 1125.[illegible] | [illegible]27 | [illegible] | [illegible] |
| 1850 | 245 | 24 | 20.1 | 15.2 | 948.[illegible] | 73 | 12.[illegible]1 | 1124.17 | 326 | [illegible]67 | 11 |
| 1875 | 242 | 25 | 20.[illegible] | 15.3 | 947.35 | 74 | 12.92 | 1125.47 | 326 | 667 | 10 |
| 1900 | 246 | 33 | 20.3 | 15.6 | 947.01 | 74 | 13.11 | 1123.51 | 327 | 667 | [illegible] |
| 1925 | 245 | 22 | 20.0 | 15.1 | 946.17 | 73 | 12.76 | 1123.[illegible] | 325 | [illegible]67 | 11 |
| 1950 | 247 | 33 | 19.9 | 15.0 | 945.34 | 73 | 12.63 | 1122.[illegible] | 324 | 667 | 1[illegible] |
| 1975 | 244 | 24 | 19.9 | 14.[illegible] | 944.50 | 72 | 12.45 | 1121.94 | 323 | 667 | [illegible] |
| 2000 | 252 | 25 | 20.1 | 14.5 | 943.66 | 71 | 12.47 | 1120.45 | 323 | [illegible]67 | [illegible] |
| 2025 | 243 | 2[illegible] | 19.3 | 14.3 | 942.82 | 70 | 12.0[illegible] | 112[illegible].51 | 32[illegible] | [illegible]67 | 1 |
| 2050 | 249 | 24 | 19.9 | 14.2 | 941.99 | 69 | 11.9[illegible] | 1119.21 | 32[illegible] | [illegible]67 | 1 |
| 2075 | 253 | 23 | 19.7 | 13.[illegible] | 941.15 | [illegible] | 11.[illegible] | 111[illegible] | 31[illegible] | [illegible] | [illegible] |
| 2100 | 245 | 20 | 19.[illegible] | 13.9 | 940.32 | 69 | 11.82 | 1117.6[illegible] | 31[illegible] | [illegible]7 | [illegible] |
| 2125 | 250 | 2[illegible] | 18.7 | 12.9 | 939.4[illegible] | 59 | 11.[illegible] | 1120.57 | 315 | 656 | 3 |
| 2150 | 253 | 23 | 18.5 | 12.7 | 938.64 | 69 | 10.92 | 1120.49 | 314 | [illegible] | [illegible] |
| 2175 | 250 | 23 | 19.[illegible] | 13.[illegible] | 937.81 | 6[illegible] | 11.57 | 1115.[illegible] | 316 | [illegible]67 | 5 |
| 2200 | 244 | 23 | 19.8 | 13.7 | 936.98 | 69 | 11.64 | 1113.7[illegible] | 31[illegible] | 667 | [illegible] |
| 2225 | [illegible]5[illegible] | 22 | 19.4 | 13.3 | 93[illegible].15 | [illegible] | 11.34 | 1114.11 | 31[illegible] | [illegible] | [illegible] |

FIGURE 31. Computer Processed Data Printout

APPENDIX I

TELEDYNAMICS METEOROLOGICAL DATA PROCESSOR -

CHANGE-OVER PROCEDURE

## APPENDIX I

### TELEDYNAMICS MET DATA PROCESSOR - CHANGE-OVER PROCEDURE

After the data processor cabinet and receiver wiring changes have been completed, the system may be converted to operation compatible with the Low Level Radiosonde by the substitution of a number of cards and connectors and by changing the positions of the appropriate switches. The change-over procedure is given below:

1. Check out the normal data processor operation with the system sonde simulator.

2. Turn off power.

3. Substitute the modified printed circuit cards for the original cards in the following locations:

   a. Data Drawer:

      J1, J30, Add J5

   b. Control Drawer:

      J102, J103, J105

      Substitute J106 with modified card J215

   c. Processing Drawer:

| | | |
|---|---|---|
| J203 | J208 | J222 |
| J204 | J209 | J226 |
| J205 | J210 | Add J218 |
| J206 | J211 | |

   Insert card J106 (removed from Control Drawer in paragraph 1.b) into card slot J215.
   Substitute modified VCO Card for original VCO Card.
   Substitute the modified program connectors P95 and P193 for the original connectors.

5. Change the jumper on the Program Card, J103 so that the processor will accept three data channels.

6. If there is no card in slot J133, insert the system spare in the J133 card slot.

7. Change the rotary switch inside the Processing Drawer from the "NORMAL" position to the "Low-Level" position.

8. Set the Reference Frequency Range switch to the "190" position.

9. Set the "Time Interval" switch to the "6" position.

10. Set switches in the GMD Receiver as follows:

    a. "Normal - Low Level" switch to "Low Level".

    b. "CF - INV" switch to "INV"

    c. "AM-FM" switch to "FM"

    d. "Broad-Sharp" switch to "Sharp"

11. Turn on power and proceed with the data processor check-out utilizing the "Low-Level Sonde Simulator".

APPENDIX II

SONEX METEOROLOGICAL DATA PROCESSOR -

CHANGE-OVER PROCEDURE

APPENDIX II

SONNEX MET DATA PROCESSOR - CHANGE-OVER PROCEDURE

After the data processor cabinet and receiver wiring changes have been completed, the system may be converted to operation compatible with the Low Level Radiosonde by the substitution of a number of cards and connectors and by changing the positions of the appropriate switches. The change-over procedure is given below:

1. Check out the normal data processor operation with the system sonde simulator.

2. Turn off power.

3. Substitute the modified printed circuit cards for the original cards in the following locations:

   a. Control Drawer:

      J102, J103, J105

   b. Processing Drawer:

| | | |
|---|---|---|
| J203 | J208 | J219 |
| J204 | J209 | J222 |
| J205 | J210 | J226 |
| J206 | J211 | Add J216 |
| | J215 | Add J217 |

   Substitute modified VCO card for the original VCO card.

4. Substitute the modified program connectors P93 and P193 for the original connectors.

5. Change the jumper on the Program Card, J103, so that the processor will accept three data channels.

6. If there is no card in slot J133, insert the system spare #2339 in the J133 card slot.

7. Set the Reference Frequency Range switch to the "190" position.

8. Set the "Time Interval" switch to the "6" position.

9. Set switches in the GMD Receiver, as follows.

   a. "Normal - Low Level" switch to "Low Level"

   b. "CF - INV" switch to "INV"

   c. "AM-FM" switch to "FM"

   d. "Broad-Sharp" switch to "Sharp"

10. Turn on power and proceed with the data processor check-out utilizing the "Low Level Sonde Simulator".

APPENDIX III

TEI-751 PRELIMINARY TESTING OF CARDS USED IN MODIFICATION

OF

TELEDYNAMICS AND SONEX MDPS FOR THE LOW LEVEL SOUNDING SYSTEM

APPENDIX III

| APPROVAL | DATE | | ENGINEERING SPECIFICATION |
|---|---|---|---|
| R J Kernery / PROJECT ENGINEER | 3/21/69 | **Bendix** Environmental Science Division BALTIMORE, MARYLAND 21204 | TYPE Test Specification |
| ENGRG MANAGER W. F... | 3/21/69 | | NUMBER TEI - 751 |
| PRODUCT ENGINEER | | | TITLE Preliminary Testing of Cards Used in Modification of Teledynamics and Sonex MDPS for the Low Level Sounding Systems |
| | | REVISION SHEET | RELEASE NO. / DATE |

RECORD OF REVISION STATUS FOR EACH SHEET

| 010 | 020 | 030 | 040 | 050 | 060 | 070 | 080 | 090 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | CHECKED | APPROVED | DATE | ECN NO. |
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| 180 | 190 | 200 | 210 | 220 | 230 | 240 | 250 | 260 | 270 | 280 | 290 | 300 | 310 | 320 | 330 | 340 | CHECKED | APPROVED | DATE | ECN NO. |
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SHEET 010 CONT. ON 020

REV.

TEST SPECIFICATION

PRELIMINARY TESTING OF CARDS USED IN MODIFICATION OF TELEDYNAMICS AND SONEX MDPS FOR THE LOW LEVEL SOUNDING SYSTEMS

1.0 PURPOSE

The purpose of this specification is to describe the tests required to confirm proper operation of the new and modified cards for the Teledynamic and Sonex Meteorological Data Processors when used in the Low Level Sounding System. These tests are preliminary ones and are to be made prior to installation of the cards into the Data Processor.

2.0 REFERENCES

2.1 Modification Specification - Teledynamic or Sonex Meteorological Data Processor

2.2 Logic and Schematic Diagrams - Teledynamic or Sonex MDPS

2.3 Instruction Manual for Meteorological Data Processor Type 3703C, Volume I of II

2.4 Logic and Schematic Diagrams for Meteorological Data Processor, Type 3703C, Volume II of II

3.0 TEST EQUIPMENT REQUIREMENTS

3.1 One voltmeter capable of one mV resolution at voltages between zero and ten volts.

3.2 One precision voltage source; adjustable from zero to ten volts.

3.3 One electronic counter; at least 0 to 200 kc range

3.4 One oscilloscope, Tektronix 535A or equivalent, with dual trace pre-amp

3.5 Power Supplies

3.5.1 Two power supplies, ± 18 volts

3.5.2 Two power supplies, ± 15 volts

3.5.3 One power supply, + 45 volts

3.5.4 One power supply, + 5 volts

3.6 One pulse generator, 200 KC, 0 to + 5 volts

3.7 One Sonde Simulator

4.0 TEST PROCEDURE

4.1 Adjust all power supplies to ± 1% of given voltage.

4.2 Pulse Standardization

4.2.1 Connect J204, J205, J206, and J208 as shown in Figure 1.

4.2.2 Observe output of Set-Reset flip-flop on scope. The period of time the flip-flop is set should be approximately .215 msec.

4.2.3 Sync. scope of trailing edge (negative) of 15 msec pulse from one-shot multivibrator J208, pin H. Set sweep rate to 5 usec/cm. Observe the following pins for proper voltage levels to determine if the counter is presetting to binary number 21:

| PIN | LEVEL |
|---|---|
| J204 F | + 5 V |
| J204 H | 0 |
| J204 N | + 5 V |
| J204 2 | 0 |
| J205 F | + 5 V |
| J205 2 | 0 |

4.2.4 Sync. scope on leading edge (positive) of pulse from one-shot multivibrator J208, pin H. Set sweep rate to 5 usec/cm. All of the pins described in 4.2.3 are to be at zero volts for 20 usec. Pins J204 F, J204 N, and J205 F should rise to + 5 volts at the end of the 20 usec delay.

4.2.5 Sync. scope on the output of the Set-Reset flip-flop, using delayed sweep. Connect the "A" input of the scope to J208 H. Monitor the pins described in 4.2.3 on the "B" input to the scope. During the 5 usec. period prior to the firing of the one-shot multivibrator, the pins should all be at + 5 volts.

4.3 Frequency Multiplication

This test will confirm that the frequency range of the VCO (multiplied) will be 1,000 Hz to 20,000 Hz for an input frequency range of 200 Hz to 4,000 Hz.

4.3.1 Connect the output of the Set-Reset flip-flop in Paragraph 4.2 to the frequency multiplication circuitry as shown in Figure 2.

4.3.2 Set Sonde Simulator frequency to a 4 KHz + 10 cps square wave (steady signal). The output of the VCO shall read 20 KHz ± 40 cps. Record Sonde Simulator frequency vs. VCO frequency by referring to the following chart:

| Sonde Simulator (Continues Signal) | VCO |
|---|---|
| 4 KHz ± 10 Hz | 20 KHz ± 40 Hz |
| 2 KHz ± 5 Hz | 10 KHz ± 40 Hz |
| 1 KHz ± 3 Hz | 5 KHz ± 40 Hz |
| 500 Hz ± 3 Hz | 2.5 KHz ± 25 Hz |
| 250 Hz ± 3 Hz | 1.25 KHz ± 20 Hz |

4.4 Channel Drop-Out Detector

4.4.1 Connect the Channel Drop-Out Detector Card J209 as shown in Figure 3.

4.4.2 Observe waveforms at TP2 and TP3 with input frequency set to 200 cps and 4 KC. See Figure 4.

4.5 Missing Channel Detector

4.5.1 Connect the Missing Channel Detector Card as shown in Figure 5.

4.5.2 With the Sonde Simulator operating normally, TP3 will remain at zero volts.

4.5.2.1 Switch Missing Channel switch on the Sonde Simulator to the "ON" position. TP3 will go to + 5 volts after the channel has been missing for 50 msec and will be reset by the .3 second one-shot. See Figure 6.

4.6 Fall-Out Detector During Reference Gate

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4.6.1 Connect J211 as shown in Figure 7.

4.6.2 During normal operation, TP 3 will be at zero volts at all times.

4.6.2.1 Switch Channel Drop-Out switch on Sonde Simulator to the "ON" position. TP2 will go to zero volts at the end of each channel. A 75 msec pulse will be present at TP3 when J201, pin C is removed from ground for each pulse on TP2. See Figure 8.

4.7 Reference Detector

4.7.1 Connect cards J215, and J218, for Teledynamics equipment; J216, and J217, for Sonex equipment; and J208 for both as shown in Figure 9.

4.7.2 Connect scope and counter to in 2 of J208 and observe 40 usec pulses at 1 KHz rate.

4.8 Reference Counter

4.8.1 Connect modified J203 card as shown in Figure 10.

4.8.2 With 200 KHz at the input (Pin B), check for 50 KHz square wave at pin 2.

4.9 Time Data and Punch Rate

4.9.1 Connect cards J102, J103, and J105 as shown in Figure 11.

4.9.2 With 50 Hz pulses at J102B, check for 1 Hz square wave at J105 14.

Bendix Environmental Science Division

ENGINEERING SPECIFICATION

TYPE Test Specification

NUMBER TEI - 751

REV

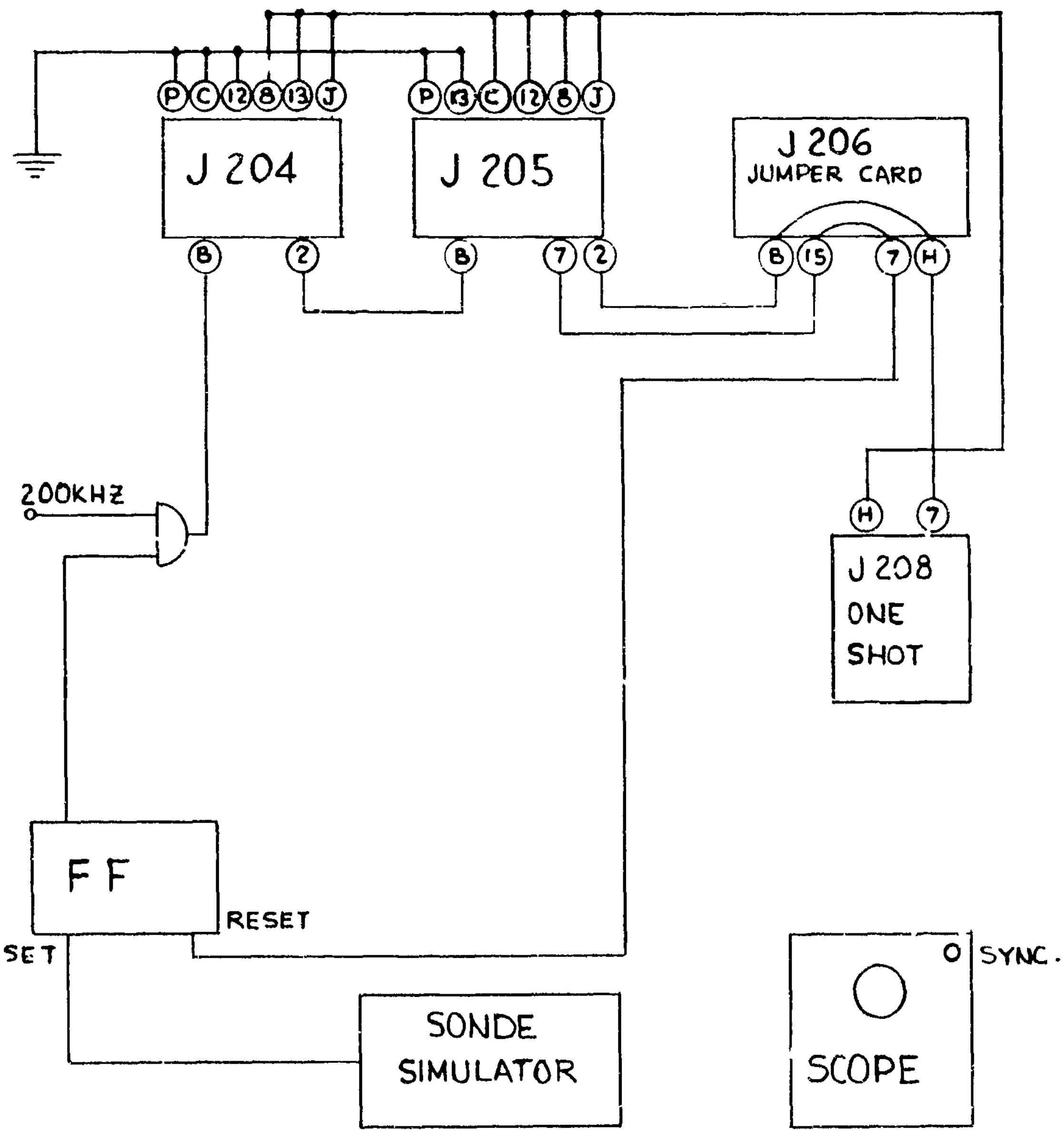


FIGURE 1

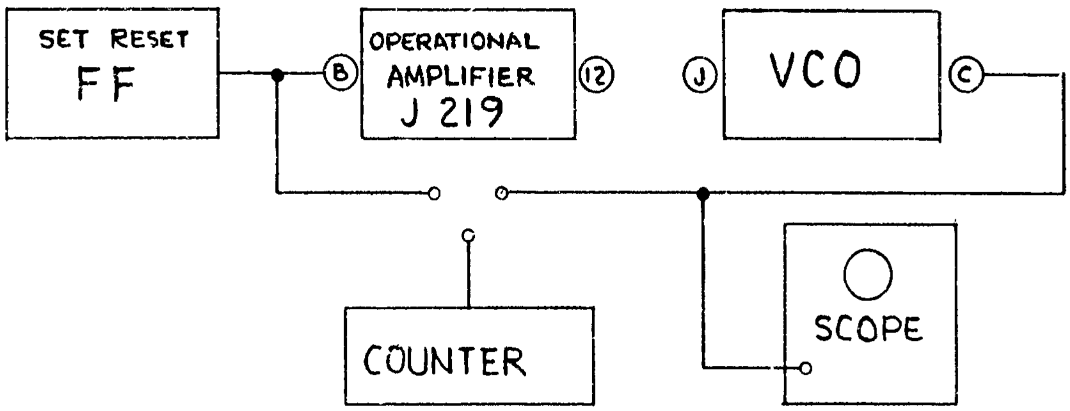


FIGURE 2

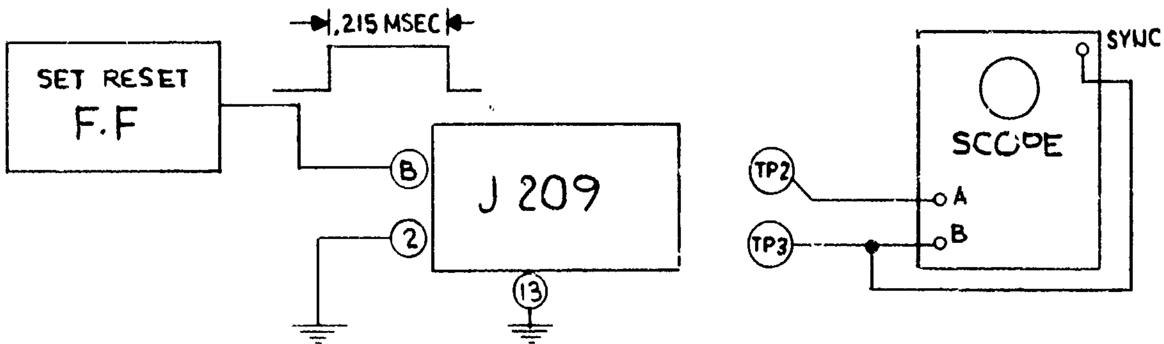


FIGURE 3

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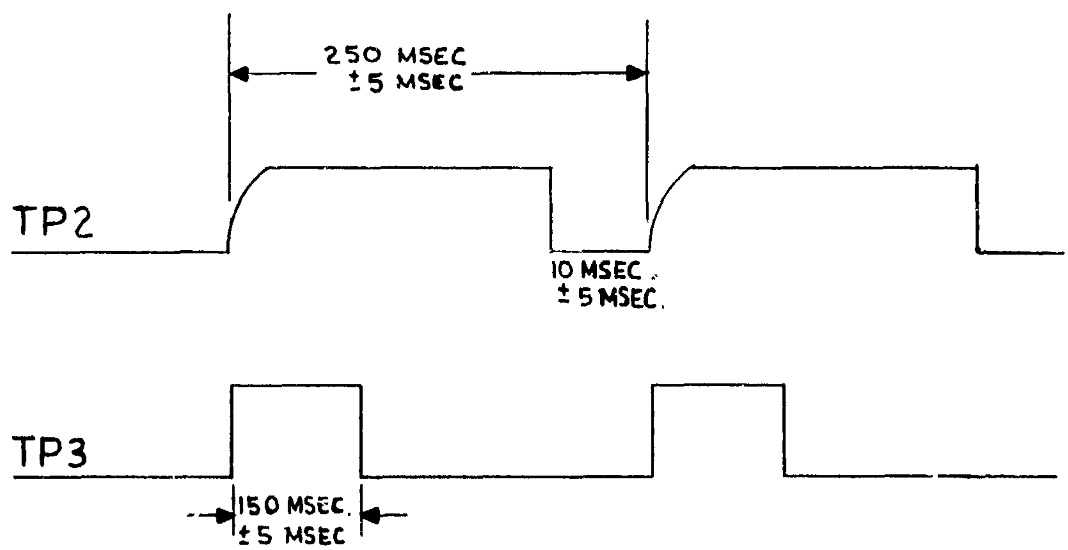


FIGURE 4

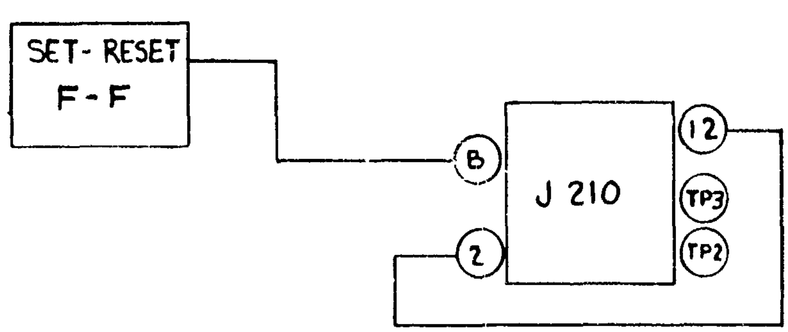


FIGURE 5

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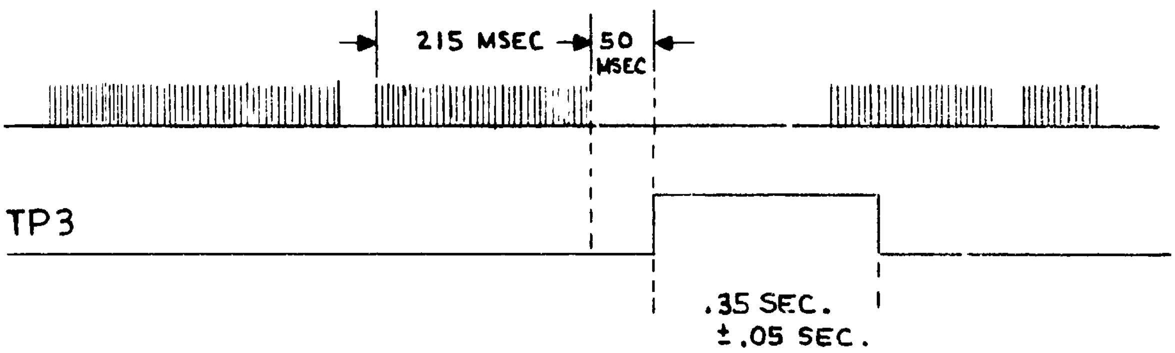


FIGURE 6

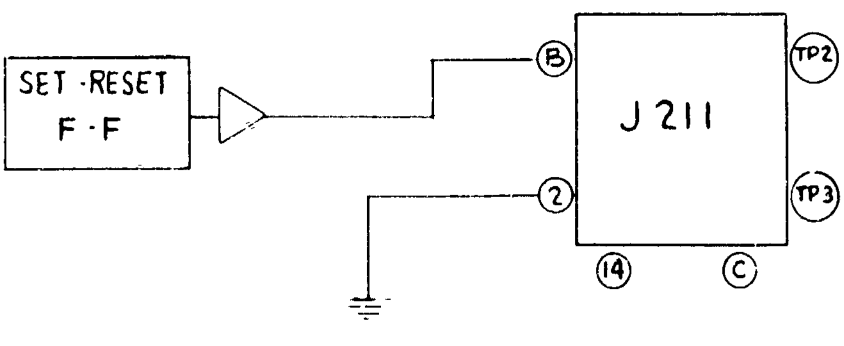


FIGURE 7

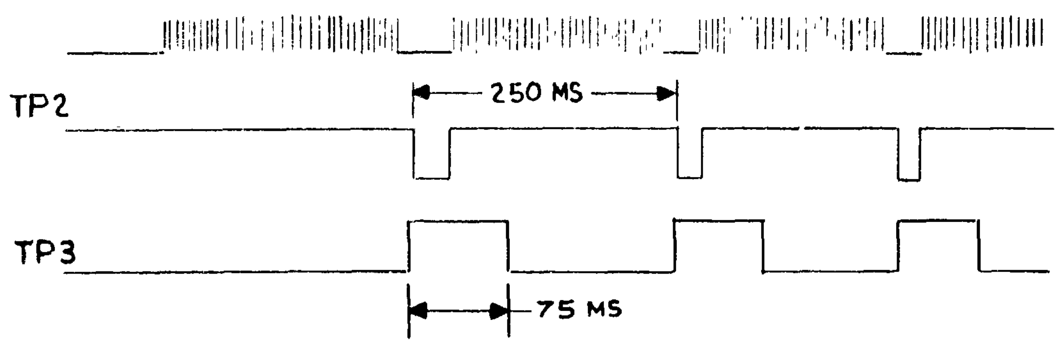


FIGURE 8

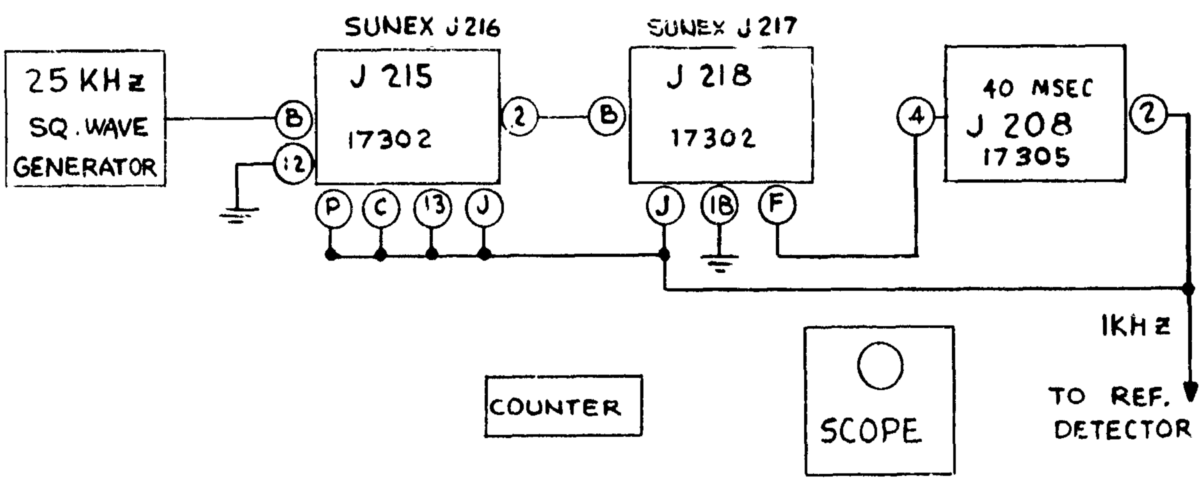


FIGURE 9

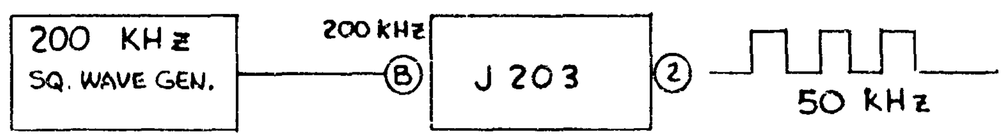


FIGURE 10

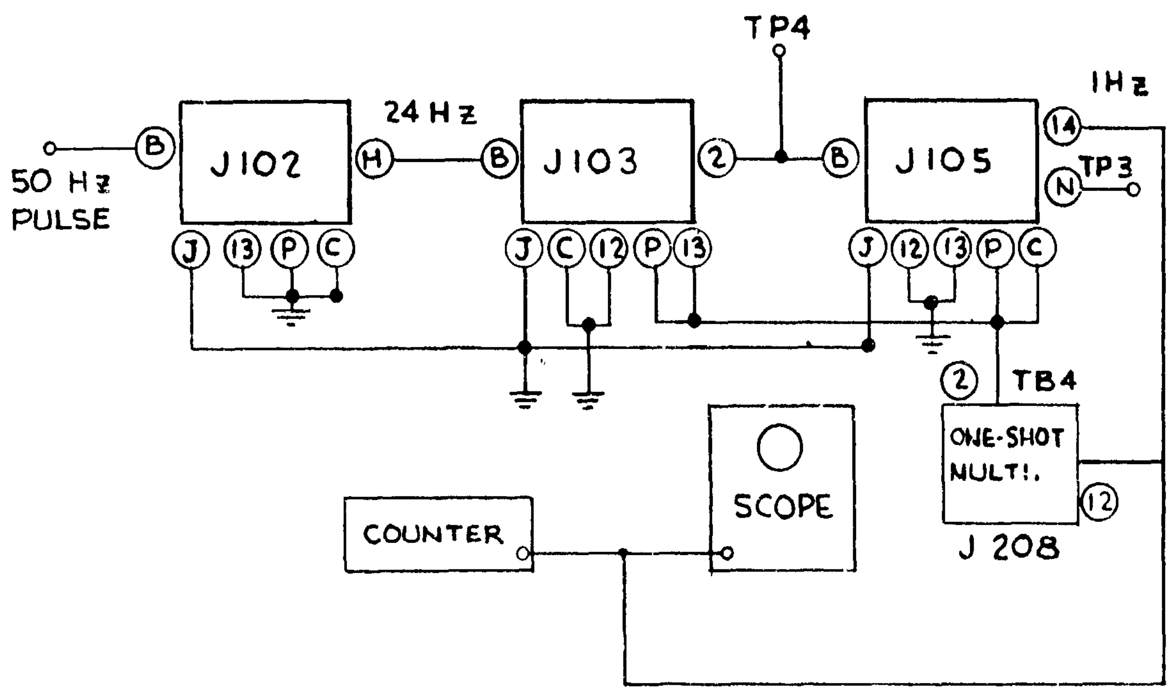


FIGURE 11

APPENDIX IV

ES-2412658 GMD-4 MODIFICATION

FOR

LOW LEVEL SOUNDING SYSTEM

APPENDIX IV

| APPROVAL | DATE | | ENGINEERING SPECIFICATION | |
|---|---|---|---|---|
| | | **Bendix** Environmental Science Division<br>BALTIMORE, MARYLAND 21204 | TYPE Test Specification | |
| PROJECT ENGINEER [illegible] | [illegible] | | NUMBER ES 2412658 | |
| ENGRG MANAGER | | | TITLE GMD-4 Modification for Low Level Sounding System | |
| PRODUCT ENGINEER | | | | |
| | | REVISION SHEET | RELEASE NO. | DATE |

RECORD OF REVISION STATUS FOR EACH SHEET

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Bendix Environmental Science Division

ENGINEERING SPECIFICATION

TYPE Test Specification

NUMBER ES 2412658

REV.

TEST SPECIFICATION - GMD-4 MODIFICATION FOR LOW LEVEL SOUNDING SYSTEM

1.0 Purpose

The purpose of this test is to verify the proper operation of the Meteorological Data Processor after it has been modified to operate in the low-level sounding system.

2.0 References

2.1 Instruction Manual for MDP type 3703-C, Volume I of II.

2.2 Logic and Schematic Diagrams for MDP type 3703-C, Volume II of II.

2.3 Logic and Schematic Diagrams, Teledynamics Meteorological Data Processor.

2.4 Modification Specification - EIR No. 719

3.0 Test Equipment Required

3.1 Sonde Simulator

3.2 Oscilloscope - Tektronix 545A or equivalent

3.3 Electronic Counter - 0 to 100 KC

3.4 Multimeter - Simpson Model 260 or equivalent

3.5 Power Supply, +5 volts, 100 ma

4.0 Testing

4.1 General - The testing will be accomplished in two parts as follows:

a) Simulated met data and programming test.

b) Simulated Met Data system test utilizing a sonde transmitter.

4.2 Simulated Met Data and Programming Test

4.2.1 Description

This test will consist of the insertion of simulated met data pulses of known frequency and duration into the met data processor at J207-12 and checking for proper waveforms and readout.

4.2.2 Procedure

4.2.2.1 Connect the output of the Sonde Simulator to pin 12 of J207. Disconnect wire from J202-16. Set the Sonde Simulator for an output of continuous 4 KHZ pulses.

4.2.2.2 Turn Sonde Simulator power on.

4.2.2.3 Observe waveform at output of the Sonde Simulator. It should appear as in Figure 1(a).

4.2.2.4 Pulse Standardization

Observe the output of flip-flop J207 - TP4. The period of time the flip-flop is set should be 215 msec for all input frequencies.

Cards J204, J205, J207-4, and J208-H form a pulse standardization circuit. The counter will count forty-three 200 KC pulses and then initiate a reset for the counter and flip-flop J207-4.

Sync. the scope on the leading edge (positive) of the 15 msec pulse at J208-H. Set the sweep rate to

REV.

5 usec/cm. Observe the following pins for proper voltage levels at end of the 15 usec delay.

| PIN | LEVEL AFTER DELAY |
|---|---|
| J204-F | +5V |
| J204-H | 0 |
| J204-N | +5V |
| J204-2 | 0 |
| J205-F | +5V |
| J205-2 | 0 |

At the start of the trace all of the above pins shall be at +5 volts.

During the 15 usec pulse period all of the above pins shall be at zero volts.

4.2.2.5 Frequency Multiplication

This test will confirm that the frequency range of the VCO will be 1,000 HZ to 20,000 HZ for an input frequency range of 200 HZ to 4000 HZ.

a) Set the Sonde Simulator frequency to a steady 4KHZ signal. The output of the VCO shall read 20 KHZ ± 100 HZ. Check Sonde Simulator frequency vs. VCO frequency by referring to the following

REV.

chart:

| Sonde Simulator | VCO |
|---|---|
| 4 KHZ ± 20 HZ | 20 KHZ ± 200 HZ |
| 2 KHZ ± 15 HZ | 10 KHZ ± 100 HZ |
| 1 KHZ ± 10 HZ | 5 KHZ ± 50 HZ |
| 500 HZ ± 10 HZ | 2.5 KHZ ± 50 HZ |
| 250 HZ ± 10 HZ | 1.25 KHZ ± 50 HZ |

Bendix Environmental Science Division

ENGINEERING SPECIFICATION

TYPE Test Specification

NUMBER ES 2412658

| REV. | | | | | | | | | | | | | | | | | | | | | | | | | | |
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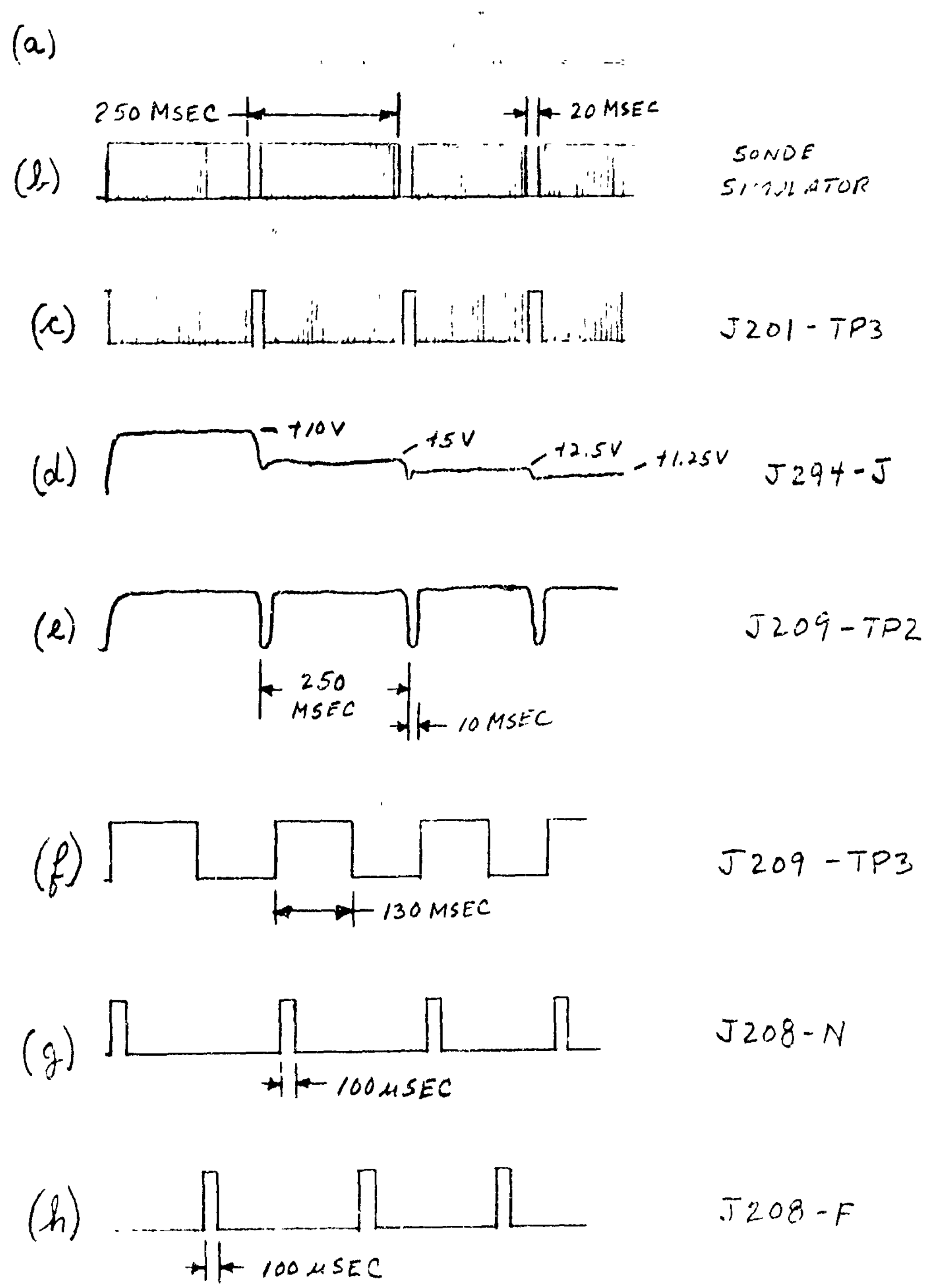


This measurement can be made by connecting an electronic counter to J201, TP2.

4.2.2.6 Set the switches on the Sonde Simulator for normal operation. Sync the scope at the "Sync" test point on the Sonde Simulator. The output of the Sonde Simulator shall appear as in Figure 1(b).

4.2.2.7 Observe the waveform at J201, TP3. It shall appear as shown in Figure 1(c).

4.2.2.8 Observe the input to the VCO (J294-J). The waveform shall appear as shown in Figure 1(d).

4.2.2.9 Observe the waveforms at J209, TP2 and TP3. They shall appear as shown in Figure 1(e) and (f), respectively.

4.2.2.10 Observe the waveform at J208-N (TP3). It shall be as shown in Figure 1(g).

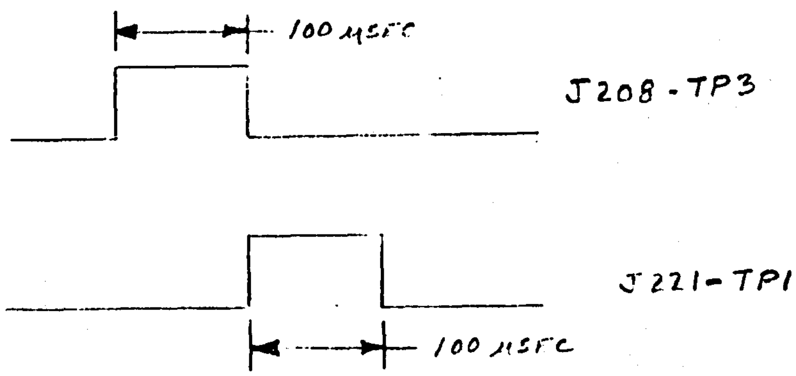
4.2.2.11 Observe the waveform at J208-F (TP1). It shall be as shown in Figure 1(h).

4.2.2.12 Observe the waveform at J210, TP3. During normal operation TP3 will remain at zero volts at all times.

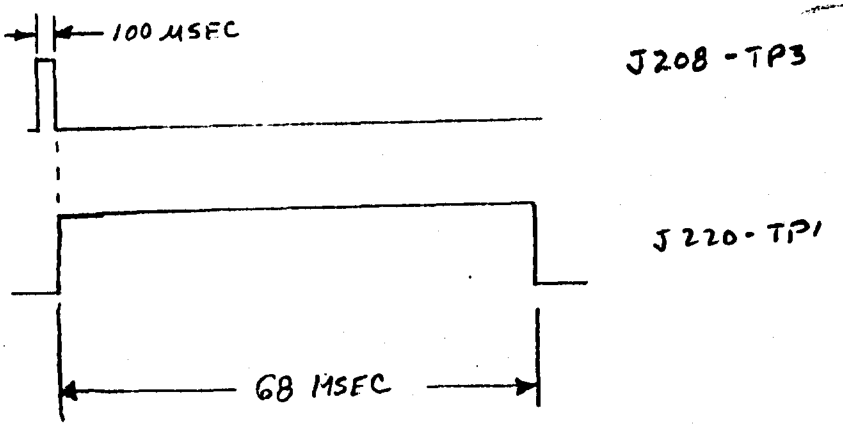
4.2.2.13 Observe waveform at J211, TP3. During normal operation, TP3 will remain at zero volts at all times.

4.2.2.14 Connect the scope to J208, pin 2. Observe 40 usec pulses at a 1 KHZ rate.

4.2.2.15 Connect "A" input of scope to J208, TP3 and "B" input to J221, TP1. Sync Scope on positive edge of signal at J208, TP3. The relationship between pulses shall appear as follows:



4.2.2.16 Move the "B" input to J220, TP1. Set S201 to the 190 position. The pulses shall appear as follows:

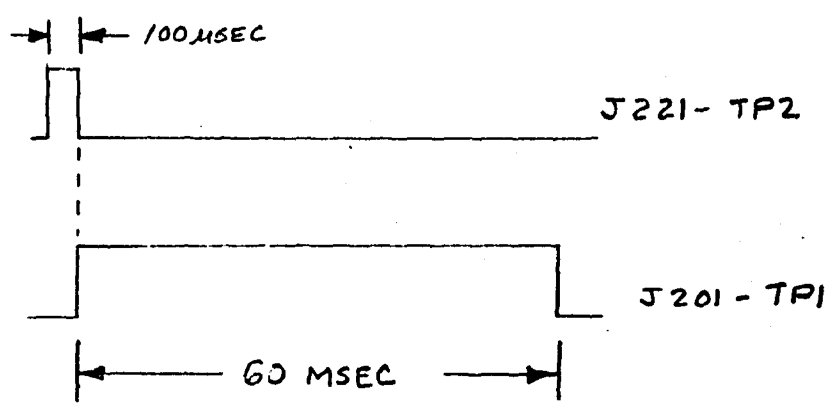


With S201 set to the 180 position, the pulse width at J220-TP1 will be 70 msec.

With S201 set to the 170 position, the pulse width at J220-TP1 will be 74 msec.

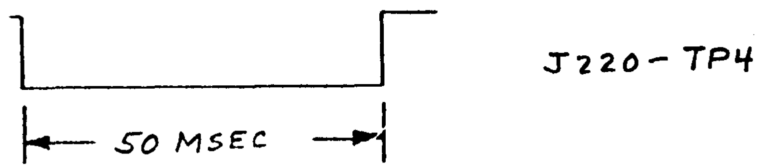
With S201 set to the 160 position, the pulse width at J220-TP1 will be 79 msec.

4.2.2.17 Sync scope on the trailing edge of the pulse at J238-TP4. Connect the "A" input to J221-TP2 and the "B" input to J201-TP1. The waveforms shall appear as follows at a rate of once per second.



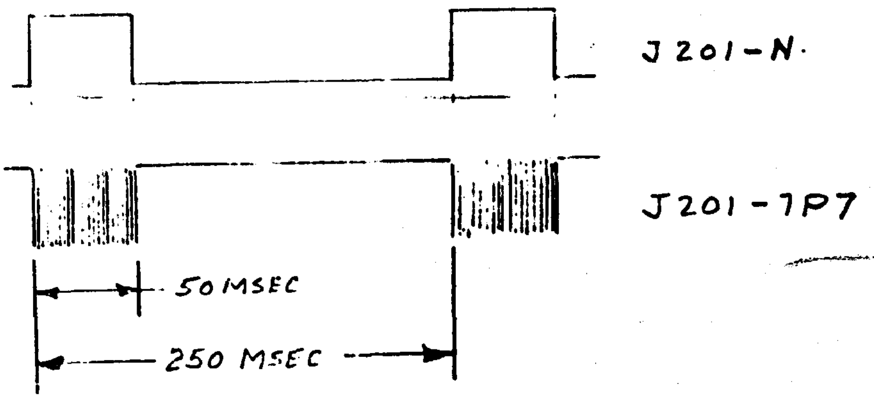
4.2.2.18 Connect scope to J203 - TP4. Observe a 50 KHZ square wave.

4.2.2.19 Sync scope on the trailing edge of the pulse at J201 - TP1. Observe J220 - TP4 for the following pulse once per second.




4.2.2.20 Monitor J221 - TP3. A positive pulse shall occur once per second and shall have a duration of 100 msec ± 20 usec.

4.2.2.21 Sync the scope on the positive edge of the pulse at J208-F. Connect input "A" to J201-N and input "B" to J201 - TP7. The waveforms shall appear as shown below:



4.2.2.22 Monitor J105-14 A positive pulse shall be present once per second.

4.2.2.23 Set the readout switch to the "6" position.

4.2.2.24 Monitor J113- TP4 (Time Data). A 100 usec positive pulse shall be present once per second.

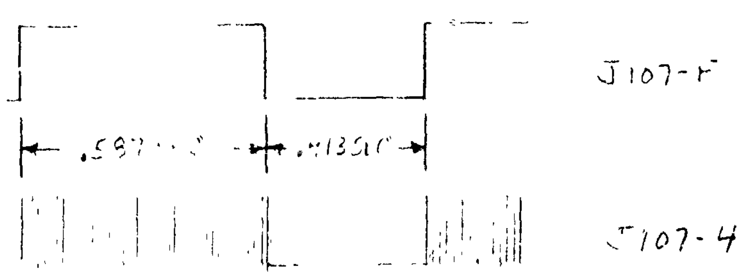
4.2.2.25 Monitor J104 - TP2 (Sequencer Start). A 80 usec positive pulse shall be present once per second.

4.2.2.26 Sync scope on Frame Sync (J221-TP3). Set sweep speed to 100 msec/cm. Confirm waveforms shown in Figure 2.

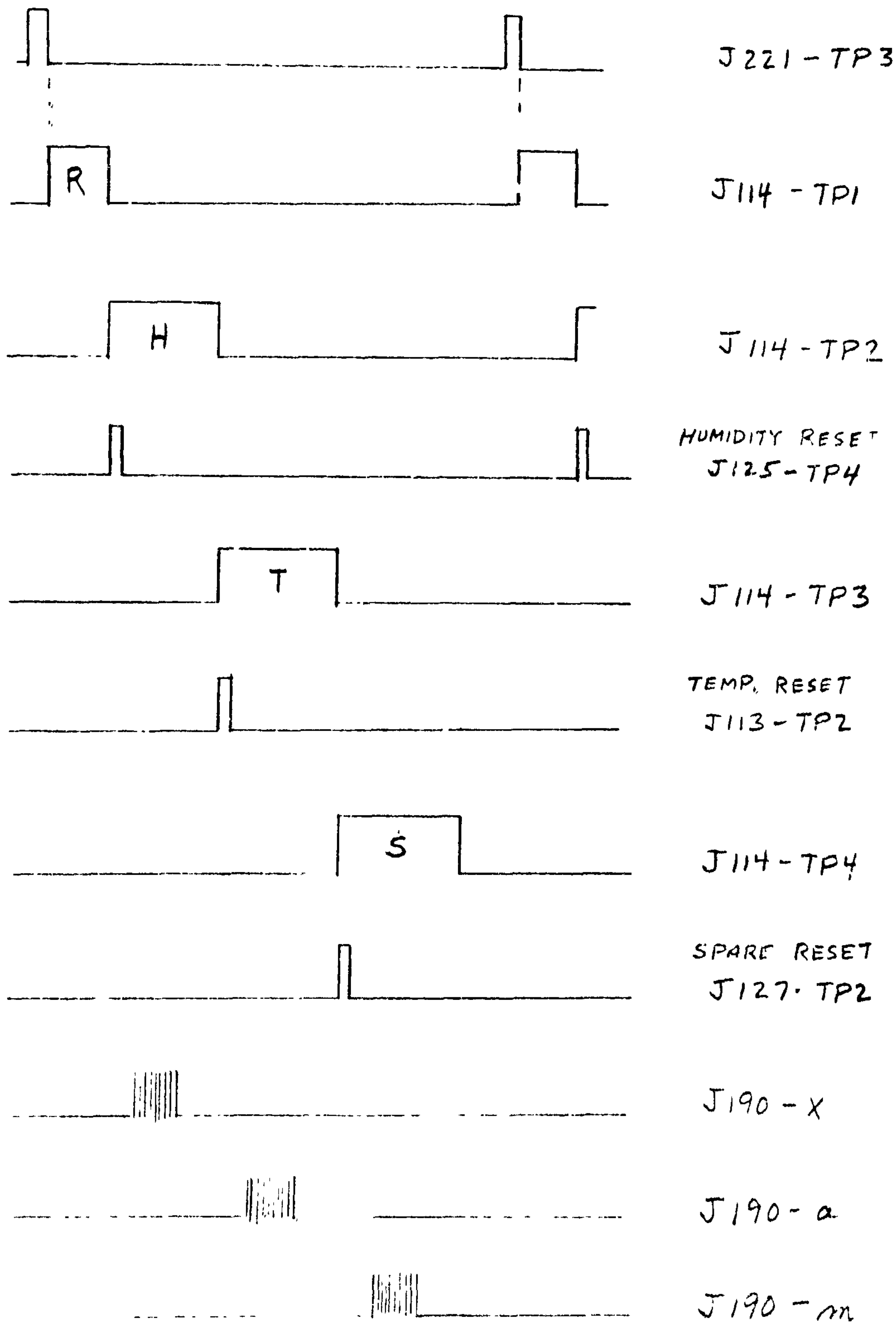
4.2.2.27 Monitor the temperature, humidity, and spare channel transfer-to-storage pulse at J125 - TP3, J113 - TP3, and J127 - TP3, respectively. Pulses of 100 usec ± 30 usec shall occur at each test point at some time between successive read-outs of each channel.

4.2.2.28 Turn on tape punch.

4.2.2.29 Sync scope with sequencer start signal, J104 - TP2. Monitor J107-F and J107-4. The waveforms shall appear as shown:



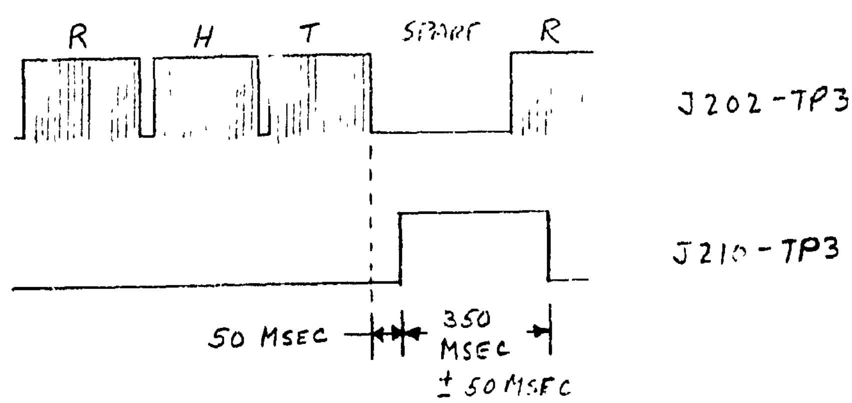
REV.


J221 - TP3
R
J114 - TP1
H
J114 - TP2
HUMIDITY RESET
J125 - TP4
T
J114 - TP3
TEMP. RESET
J113 - TP2
S
J114 - TP4
SPARE RESET
J127 - TP2
J190 - x
J190 - a
J190 - m

4.2.2.30 Punch out a tape for one minute and then print it. The readout shall appear as shown in figure 3.

4.2.2.31 Set missing channel switch "1" on the Sonde Simulator to the "out" position.

4.2.2.32 Connect scope input "A" to J202 - TP3 and input B to J210 - TP3 Sync scope at the "sync" test point on the Sonde Simulator. Observe the following waveforms:



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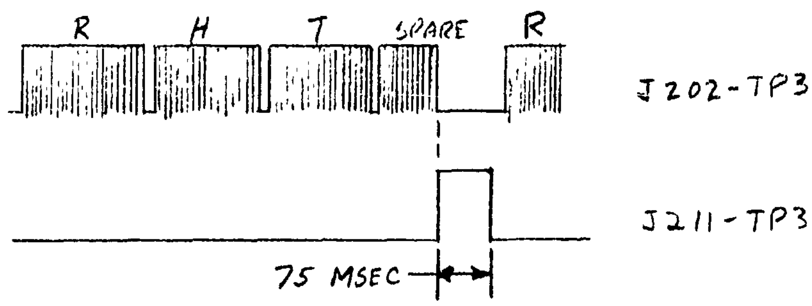
4.2.2.33 Observe the print-out to confirm a zero in the spare channel location.

4.2.2.34 Connect scope input "A" to J202 - TP3 and input "B" to J211 - TP3. Sync scope at the "sync" test point on the Sonde Simulator. Observe the following waveforms:




4.2.2.35 Observe the print-out to confirm a zero in the spare channel location.

4.3 Simulated Met Data System Test

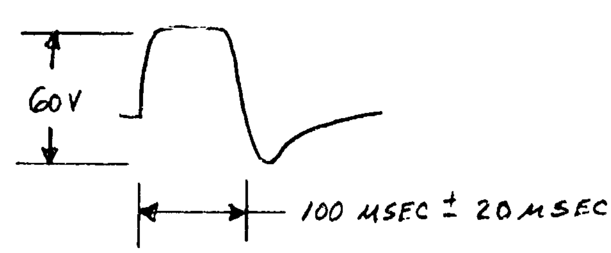
4.3.1 Description

This test will utilize a low level radiosonde or a modified AMQ-9 radiosonde to transmit simulated met data. The met data section of the sonde will be replaced by the Sonde Simulator so that known data will be transmitted.

4.3.1.1 Connect the equipment as shown in Figure 4.

4.3.1.2 Turn on AMQ-9 radiosonde.

4.3.1.3 Monitor pin 6 of V1008 in the receiver. The output shall appear as shown below:




4.3.1.4 Monitor met data at J202 - TP3 in the data processor to confirm proper pulse width and format.

4.3.1.5 Repeat paragraphs 4.2.2.30 through 4.2.2.35.

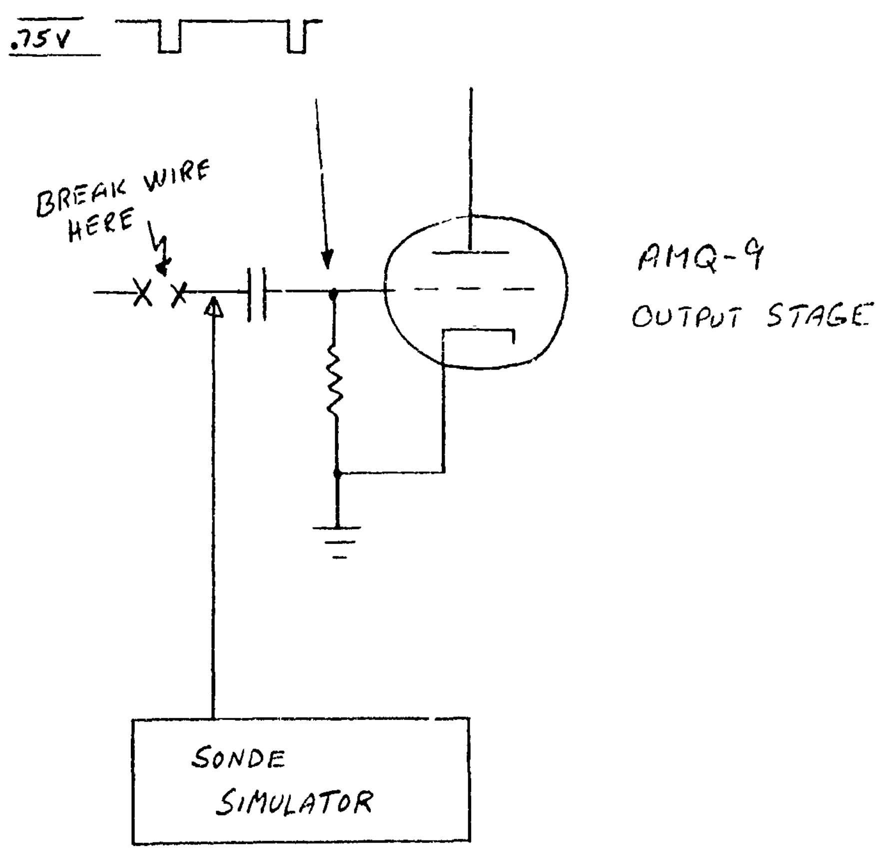



Figure 4.

APPENDIX V

ES-2410806 TEST SPECIFICATION

LOW LEVEL RADIOSONDE

APPENDIX V

| APPROVAL | DATE |
|---|---|
| R A Ramsey PROJECT ENGINEER | 3/17/69 |
| ENGRG MANAGER W E Streichert | 3/20/69 |
| PRODUCT ENGINEER | |
| | |

Bendix Environmental Science Division
BALTIMORE MARYLAND 21204

REVISION SHEET

| ENGINEERING SPECIFICATION | |
|---|---|
| TYPE | |
| NUMBER ES-2410806 | |
| TITLE TEST SPECIFICATION LOW LEVEL RADIOSONDE | |
| RELEASE NO. | DATE |

RECORD OF REVISION STATUS FOR EACH SHEET

| 010 | 020 | 030 | 040 | 050 | 060 | 070 | 080 | 090 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | CHECKED | APPROVED | DATE | ECN NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| 180 | 190 | 200 | 210 | 220 | 230 | 240 | 250 | 260 | 270 | 280 | 290 | 300 | 310 | 320 | 330 | 340 | CHECKED | APPROVED | DATE | ECN NO. |
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RECORD OF REVISION STATUS FOR ADDED SHEETS

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SHEET 010 CONT. ON 020

TEST SPECIFICATION - LOW LEVEL RADIOSONDE

1.0 Purpose

The purpose of this specification is to describe the test procedures necessary to verify proper operation of the low level radiosonde.

2.0 References

2.1 Design Plan for Telemetry Subsystem of a Low Level Sounding System.

2.2 Low Level Radiosonde Schematic Diagram
Bendix Corp., Environmental Science Division
Drawing No. 32-1014-002.

2.2 Low Level Radiosonde Circuit Board Assembly Drawing

3.0 Test Equipment Requirements

3.1 Oscilloscope, Tektronix 545A or equivalent

3.2 Electronic Counter, 0 to 100 KC or better

3.3 Power Supply, 0 to 100 ma, variable 3.0 to 60 volts

3.4 Power Supply, 0 to 100 ma, variable 10 to 14 volts

3.5 Decade Resistance Box, 0 to 1 MEG $\Omega$

3.6 Signal Generator, Amplitude modulated, 390 to 415 mcs

3.7 Phase Meter

1. Scope

This specification describes the specifications and testing procedures for the prototype models of the Low Level Radiosonde.

2. Service Conditions

2.1 Temperature - The radiosonde shall be capable of operating over the temperature range of +140°F to 0°F without degradation in performance.

2.2 Voltage - The radiosonde shall operate from the following DC voltage:

| | Minimum | Nominal | Maximum |
|---|---|---|---|
| a. | -4.0V | -4.5V | -5.0V |
| b. | -12.0V | -13.0V | -14.0V |
| c. | -17.0V | -18.0V | -19.0V |

3. REQUIREMENTS

3.1 Electrical

3.1.1 Receiver

3.1.1.1 Tuning Range - The receiver shall be tunable over the frequency range of 400 to 406 MHZ.

3.1.1.2 Sensitivity - The sensitivity over the range of 400 to 406 MHZ shall be 50 microvolts or less.

3.1.1.3 Selectivity - The receiver selectivity at minimum supply voltage (see 2.2) shall be at 50 db down at 391 and 415 MHZ from that at 400 and 406 MHZ with the receiver set to 403 ± 1.0 MHZ.

3.1.2 Meteorological Pulse Generator

3.1.2.1 Reference Frequency - With the reference resistor connected to -4.5 volts, the meteorological pulse generator fréquency shall be identified as the reference frequency, and shall be between 3900 and 4100 cps.

3.1.2.2 Data Frequencies

a. With the reference resistor connected to -4.5 volts through a 28.7K ± 1K resistor, the frequency of the meteorological pulse generator shall be 4/5 that of the reference frequency.

b. With the reference resistor connected to -4.5 volts through a 446K ± 7K resistor, the frequency of the meteorological pulse generator shall be 1/5 that of the reference frequency.

3.1.2.3 Pulse Length - The pulse length of the meteorological pulse generator shall be 50 usec ± 15 usec.

3.1.2.4 Reference Frequency vs. Voltage - The change in reference frequency shall not exceed ± 60 HZ when the supply voltage is varied over the range given in paragraph 2.2.

3.1.3 Clock Generator

3.1.3.1 Frequency - The clock generator frequency shall be 4.0 HZ ± .1 HZ with the supply voltage set to -4.5 volts. At supply voltages of -4.0 volts and -5.0 volts, the frequency shall be 4.0 HZ ± .25 HZ.

3.1.4 Met Data Blanking Pulse - The met data blanking pulse shall be between 18 and 25 milliseconds in length when the supply voltage is varied between -4.0 volts and -5.0 volts.

3.1.5 Transmitter

3.1.5.1 VSWR - The voltage standing wave ratio, as measured at the input to the transmission line, shall not exceed 1.25 as referred to a 50 ohm impedance, when measured in the unit. This is a design test only.

3.1.5.2 Frequency Range - The R.F. oscillator shall be tunable over the range of 1660 to 1700 mcs. and shall be set to 1680 ± 4 mcs prior to delivery.

3.1.5.2 Power Output - The radiated power output over the range of 1660 to 1700 mcs shall be at least 180 mw.

3.1.5.3 Collector Current - With the maximum operating voltages of 2.2, the R.F. oscillator collector current shall not exceed 100 milliamperes.

3.1.6 Modulation

3.1.6.1 Ranging Signal Modulation - The ranging signal shall frequency modulate the 1680 MHZ carrier with a deviation of 180 KHZ min., 250 KHZ max. and show no signs of regeneration.

3.1.6.2 Meteorological Data Modulation - The meteorological data from the met data oscillator shall frequency modulate the 1680 MHZ carrier with a deviation of 400 KHZ min., 800 KHZ max.

3.1.7 Phase Shift - The changes in the range signal phase shift shall not exceed the following values.

| REASON FOR CHANGE | MAXIMUM CHANGE |
|---|---|
| a. Power Supply variation (-12V to -14V) | 10 degrees |
| b. Change in received signal strength between 200 microvolts and 20 MV. | 15 degrees |

4.0 Module Testing

4.1 Met Data Generator and Commutator

4.1.1 Connect Commutator module C and Met Data Generator module D as shown in figure 1.

4.1.2 Set all test tool switches to position 1 and the sensor decade resistance box to zero ohms. Set decade resistance box (R32) to 27K and decade capacitance box (C20B) to 500 pf.

4.1.3 Adjust C20B on module D for an output frequency of 4 KHZ ± 50 HZ.

4.1.4 Set S2 to position 2. The output frequency shall not differ by more than ± 2 HZ from the frequency of 4.1.3.

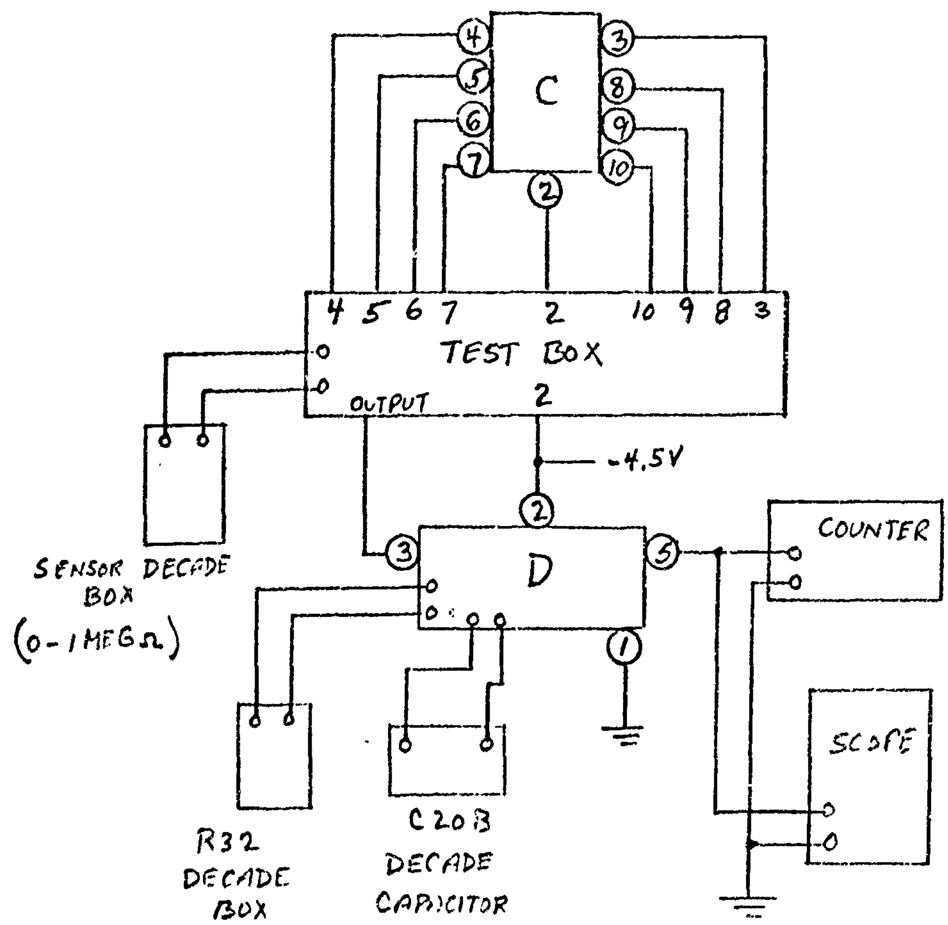



FIGURE 1

4.1.5 Commutator resistance test. With the test tool switches set to the positions shown in Table I, the measured frequencies shall not differ by more than 4 HZ from the frequency of 4.1.4.

TABLE I

| Test | S1 | S2 | S3 thru S9 |
|---|---|---|---|
| Resistance | 1 | 2 | 1 |
| " | 2 | 2 | 1 |
| " | 3 | 2 | 1 |
| " | 4 | 2 | 1 |

Note: Compliance on the data sheet.

4.1.6 Commutator Leakage Test.

4.1.6.1 With the test tool switches set to the positions shown in Table II, the measured frequencies shall not differ by more than 4 HZ from the frequency of 4.1.4

TABLE II

| Test | S1 | S2 thru S6 | S7 | S8 | S9 |
|---|---|---|---|---|---|
| Leakage | 1 | 2 | 1 | 1 | 1 |
| " | 2 | 2 | 1 | 1 | 1 |
| " | 3 | 2 | 1 | 1 | 1 |
| " | 4 | 2 | 1 | 1 | 1 |

Note: Compliance on the data sheet.

4.1.6.2 With the test tool switches set to the positions shown in Table III, the measured frequencies shall not differ from each other by more than 5 HZ.

TABLE III

| Test | S1 | S2 | S3 | S4, S5 S6 | S7 | S8 | S9 |
|---|---|---|---|---|---|---|---|
| Leakage | 2 | 2 | 2 | 2 | 2 | 1 | 1 |
| " | 3 | 2 | 2 | 2 | 1 | 2 | 1 |
| " | 4 | 2 | 2 | 2 | 1 | 1 | 2 |
| " | 4 | 2 | 1 | 2 | | | |

Note: Compliance on the data sheet.

4.1.7 Frequency response.

Set the test tool switches to the following positions:

| S1 thru S6 | S7 | S8 | S9 |
|---|---|---|---|
| Position 2 | 1 | 2 | 2 |

With the sensor decade box set at zero ohms, note the reference frequency. It shall be 4000 HZ ± 50 HZ. The frequency is adjusted by varying the value of C20B (capacitance box). Increase the setting of the sensor decade box until the frequency equals eight-tenths of the reference frequency. Record resistance value. Record resistance values corresponding to frequencies of .5, .2, and .1 of the reference frequency. The resistance values shall fall within the tolerance shown in Table IV.

TABLE IV

| FREQUENCY (% of REF.) | RESISTANCE |
|---|---|
| 100 | 0 |
| 80 | 28.7K ± 1K |
| 50 | 112.6K ± 3K |
| 20 | 446K ± 7K |
| 10 | 995K ± 15K |

4.1.8 If the resistances do not fall within the tolerances of Table IV, adjust R32 in module D by observing the following rules:

a. If the resistances are too high, decrease R32.

b. If the resistances are too low, increase R32.

Repeat 4.1.7.

4.1.9 After response curve has been adjusted to specified tolerances, proceed as follows:

a. Install closest 5% resistor for R32.

b. Install closest 5% capacitor for C20.

c. Run a response curve and record sensor resistor values on the data sheet. The resistance values shall be within the tolerances shown in Table III. Record the reference frequency. Repeat at supply voltages of -4.0 and -5.0 volts.

4.1.10 Pulse width

Record the pulse width of the met data generator at the reference frequency. It shall be 50 usec ± 15 usec. Record on the data sheet. Repeat at supply voltages of -4.0 and -5.0 volts.

4.2 Commutator Clock, Decoding, and 20 MSEC Pulse Generator

4.2.1 Connect modules A and B as shown in figure 2. Connect a decade resistance box in place of R18 and set it to 39K. Connect a decade resistance box in place of R23 and set it to 15K.

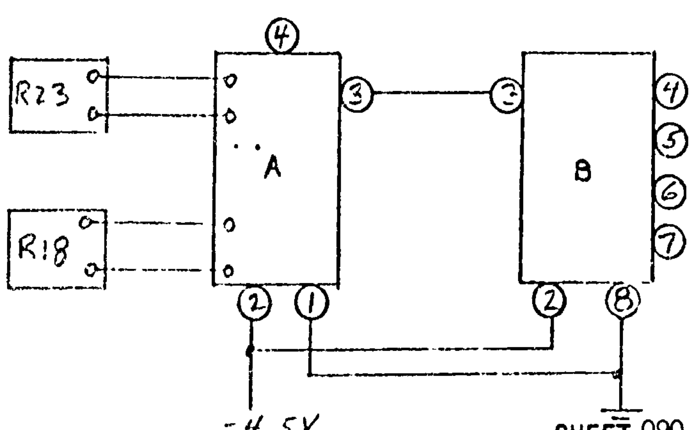



FIGURE 2

4.2.2 Connect the scope and counter to pin 3 of module A. The output shall be approximately a square wave (The period of time the waveform is high shall be within ± 20% of the period of time the waveform is low). Adjust the value of R18 (decade box) until the period is between .249 and .256 seconds. Note the settings of the decade box. Remove the decade box and install a 5% resistor with the value closest to the decade box setting. Record resistor value on the data sheet.

4.2.3 Adjust the value of R23 (decade box) until the pulse width at pin 4, module A is between 19 and 24 msec. Remove the decade box and install a 5% resistor with value closest to the decade box setting. Record resistor value on the data sheet.

4.2.4 Measure the frequency and pulse width and record on the data sheet.

4.2.5 Sync the scope externally on the positive edge of the signal on module B, pin 4. Connect the "A" input to the scope to module B, pin 4. Connect the "B" input to the scope to the various points shown in figure 3. Conform proper waveforms and record required data on data sheet.

4.2.6 Repeat 4.2.4 and 4.2.5 at supply voltages of -4.0 volts and -5.0 volts. Record data.

4.3 <u>81.94 KHZ Amplifier (Module F)</u>

4.3.1 Connect an 81.94 KHZ sine wave source to pin 3 of the 81.94 KHZ amplifier module (Module F). Set the amplitude to 100 MV ± 20 MV peak-to-peak.

4.3.2 Connect a 1000 ohm load resistor between pin 4 and ground.

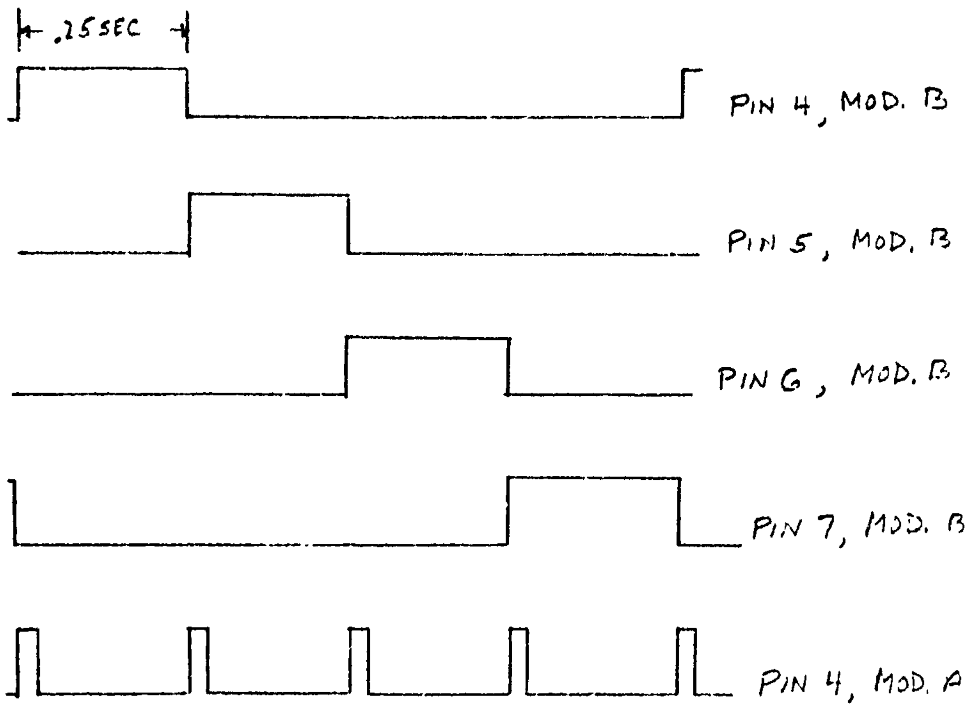



FIGURE 3

4.3.3 Observe an 81.94 KHZ sine wave at the output (pin 4) of the amplifier. Adjust coil L6 for maximum output signal. Vary the frequency of the sine wave generator above and below 81.94 KHZ to assure that the circuit is peaked to 81.94 KHZ. Note compliance on the data sheet.

4.4 Receiver

Connect the receiver module (module E) to the 81.94 KHZ amplifier module (module F). An amplitude modulated signal generator, capable of supplying 390 to 415 mcs, shall be used for these tests. The R.F. carrier of the signal generator shall be 25% amplitude modulated by a 81.94 KHZ sine wave signal source. The signal generator shall be directly coupled to the receiver. A wide band oscilloscope shall be connected to the output of the 81.94 KHZ amplifier. A synchronization lead is required from the 81.94 KHZ source to the external sync source of the oscilloscope.

4.4.1 Receiver Tuning Range

Connect the output of the signal generator directly to the input of the receiver module. Set the signal generator output level to 1 millivolt at 400 MHZ. By adjusting the tuning capacity in the receiver, the ranging signal amplitude shall peak at 400 MHZ. Repeat the above with the signal generator set to 406 MHZ. Note compliance on data sheet.

4.4.2 Sensitivity

With the signal generator output directly connected to the receiver, and the receiver and signal generator tuned to the same frequency within the band 403 ± 3 MHZ, adjust the output level of the signal generator to the point where the ranging signal is just discernible on the oscilloscope. The signal generator output shall be no greater than 50 microvolts. Record on data sheet.

4.4.3 Selectivity

With the signal generator output directly connected to the receiver and the receiver and signal generator tuned to the same frequency within the band 403 ± .25 MHZ, adjust the output level of the signal generator until the ranging signal is just discernible on the oscilloscope. The receiver sensitivity shall be down at least 50 db at the minimum and maximum frequencies from that at 403 ± .25 MHZ.

4.4.4 Internal Phase Shift

With the signal generator output directly connected to the receiver and signal generator tuned to the same frequency within the band 403 ± .25 MHZ, performed the following tests:

a. Phase Shift vs. Signal Strength -

Adjust the output of the signal generator to 200 microvolts and then to 20 millivolts. The change in the phase angle shall not exceed 12 degrees. Record on data sheet.

b. Phase Shift vs. Supply Voltage -

Adjust the output of the signal generator to 1 millivolt and the power supply to 12 ± 0.1 volt, then 14 ± .01V. The change in the phase angle shall not exceed 10 degrees. Record on data sheet.

4.5 Transmitter Tests - The following transmitter tests shall be performed with the output of the transmitter directly connected to an r.f. power meter through suitable 50 ohm coaxial connectors unless otherwise specified.

4.5.1 Collect Current

The collector current, as measured with a milliammeter of at least ± 1% accuracy, shall be 100 milliamps maximum at 1680 ± 4 MHZ with the power supply set to -18 volts. Record on data sheet.

4.5.2 Power Output

The r.f. power output shall be at least 180 milliwatts at a supply voltage of -18 ± .1 volts. Record on data sheet.

4.5.3 Frequency Range

With the transmitter connected to the antenna, the transmitter frequency shall be set to 1680 ± 4 MHZ as indicated by a cavity wave meter and a suitably positioned pick-up loop. Note compliance on data sheet.

REV. A

5.0 Radiosonde Tests - These tests shall be performed with the radiosonde completely assembled.

5.1 Modulation

With the signal generator set to 403 ± 1 MHZ and 25% amplitude modulated by a 81.94 KHZ sine wave, set the signal generator output level to 1 MV. The signal generator shall be directly coupled to the receiver. Adjust the amplitudes of the ranging and met data signals to obtain a composite waveform at the input to the transmitter as shown in figure 4.

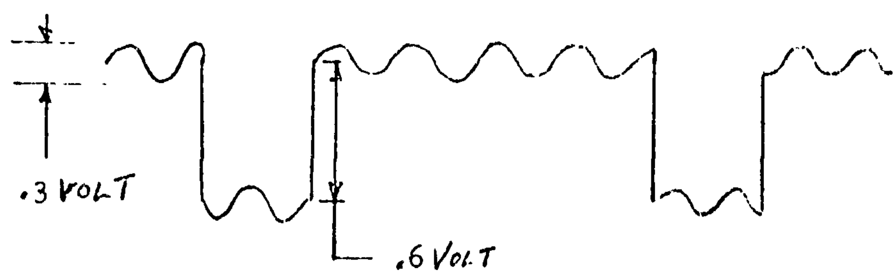
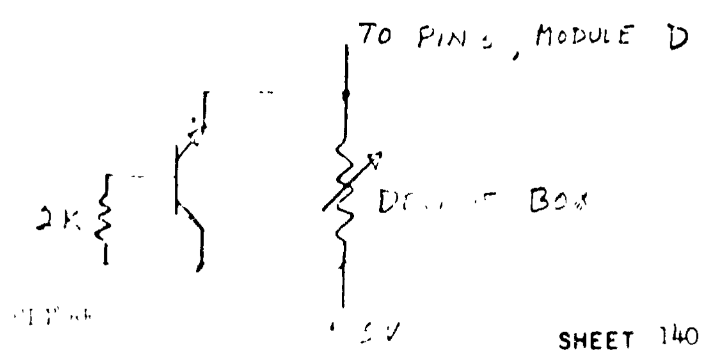



FIGURE 4

5.2 Met Data Generator Response

Disconnect the wire at pin 3 of the met data generator module "D". Connect to the circuit shown in figure 5. Record resistance values vs. ratio on data sheet no. 5 for voltages of 4.5, 4.0, and 5.0 volts. This test is to be performed with the transmitter operating.



Bendix Environmental Science Division

ENGINEERING SPECIFICATION

TYPE

NUMBER ES-2410806

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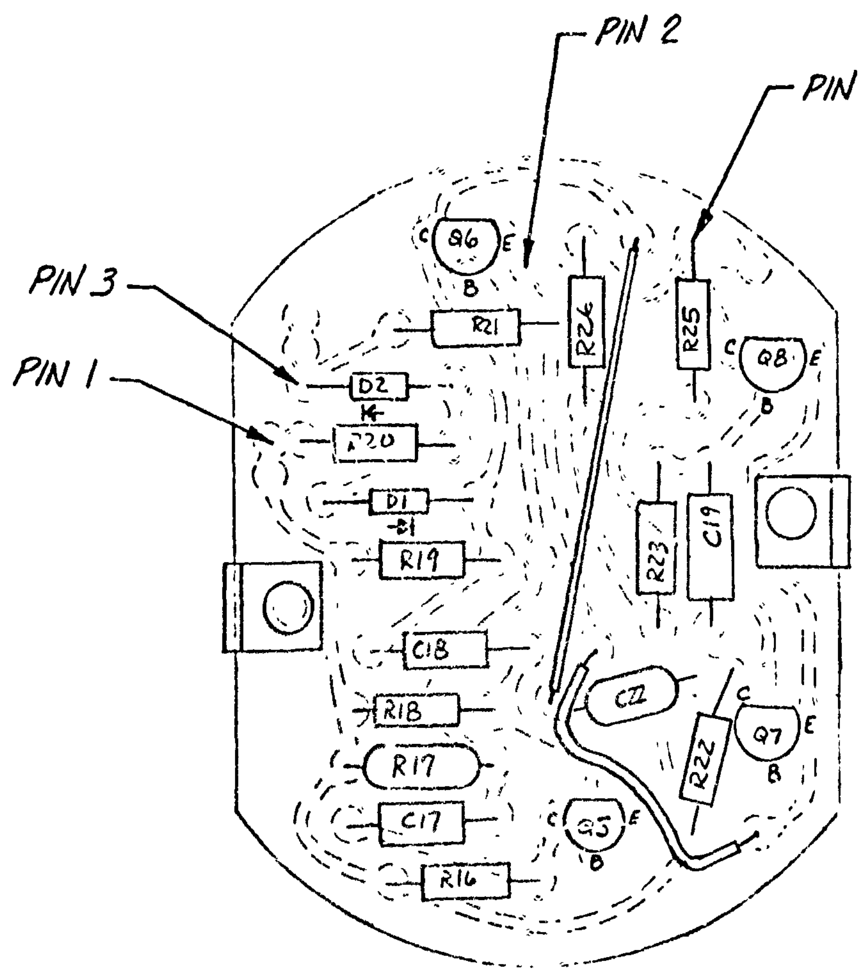
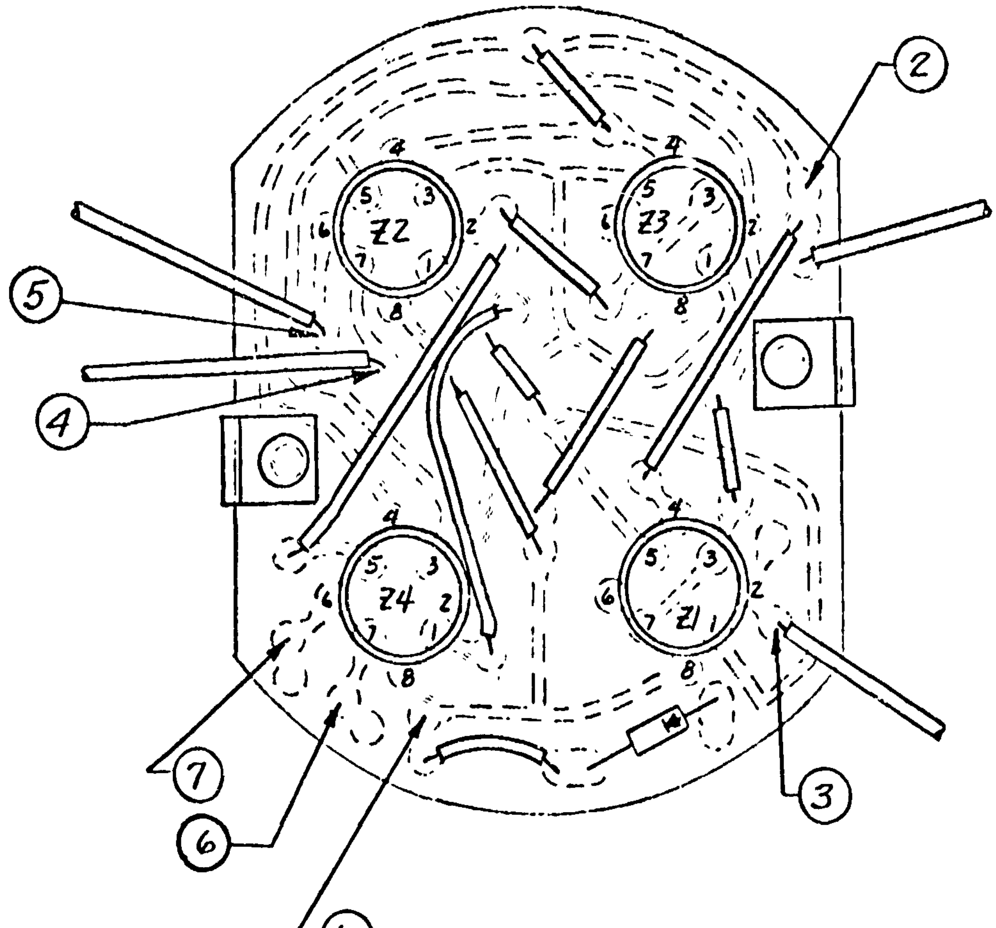



MODULE "A"
COMMUTATOR CLOCK MODULE
2410780

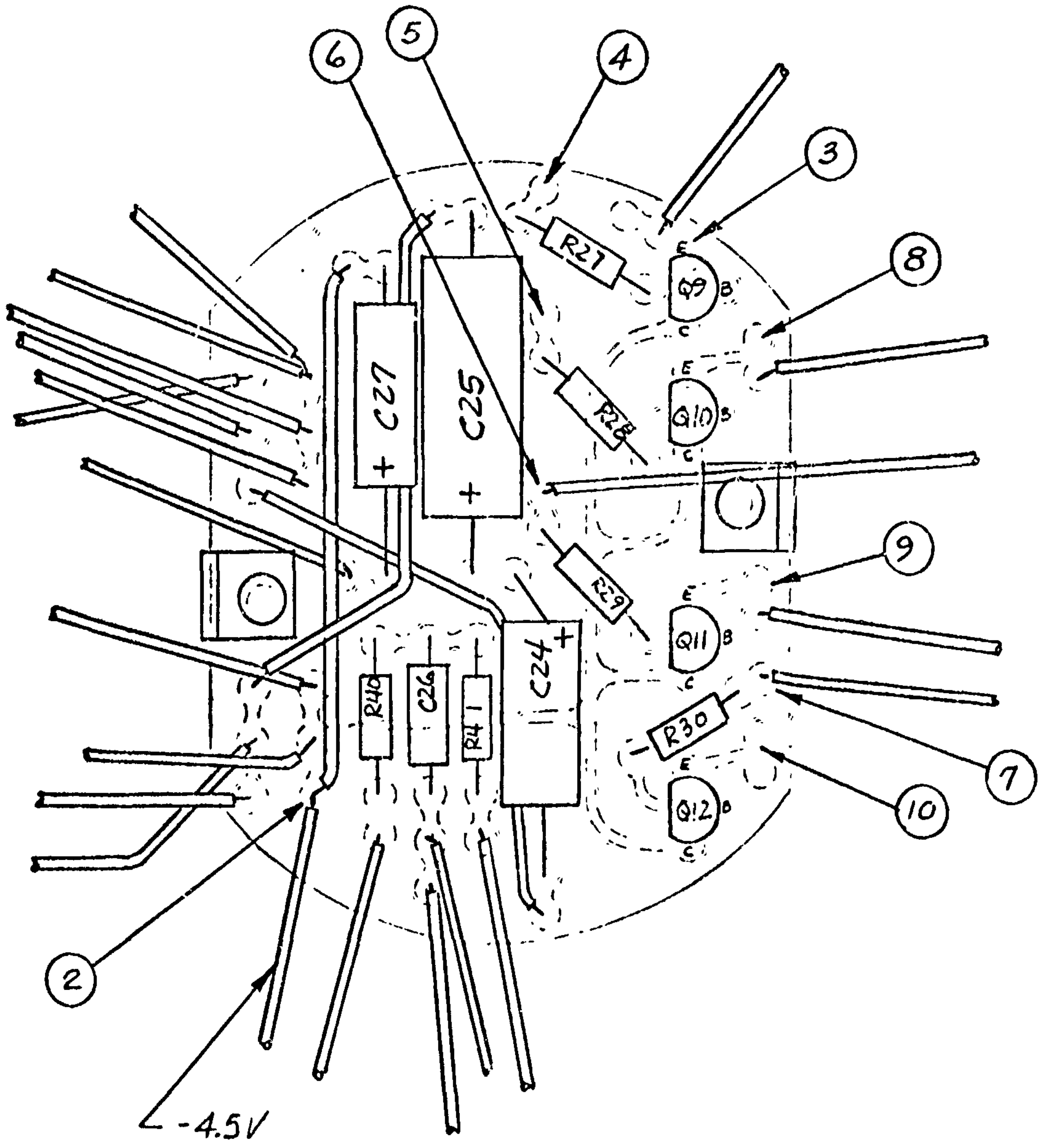
SHEET 150 CONT ON 160

| REV | A |
|---|---|



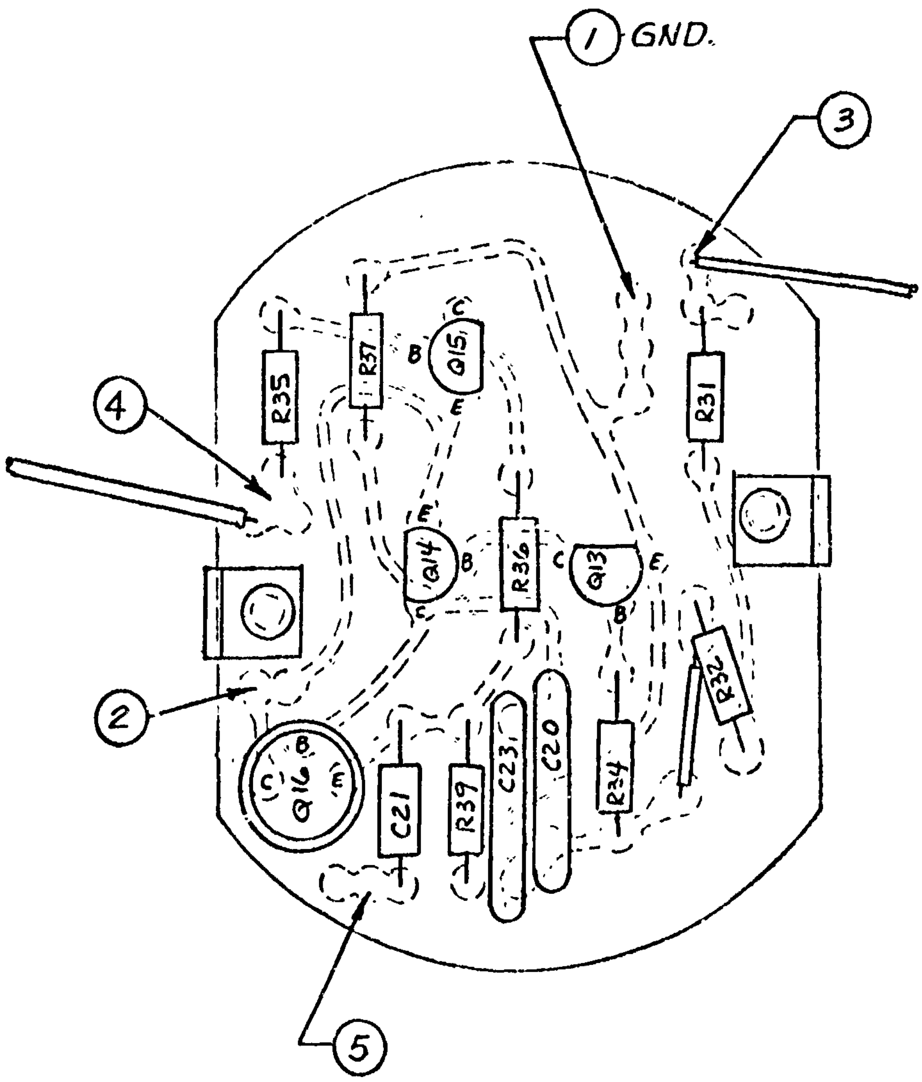

MODULE "B"
COMMUTATOR CIRCUIT
2410778

| REV. | A | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|




MODULE "C"
SWITCHING CIRCUIT
2410779

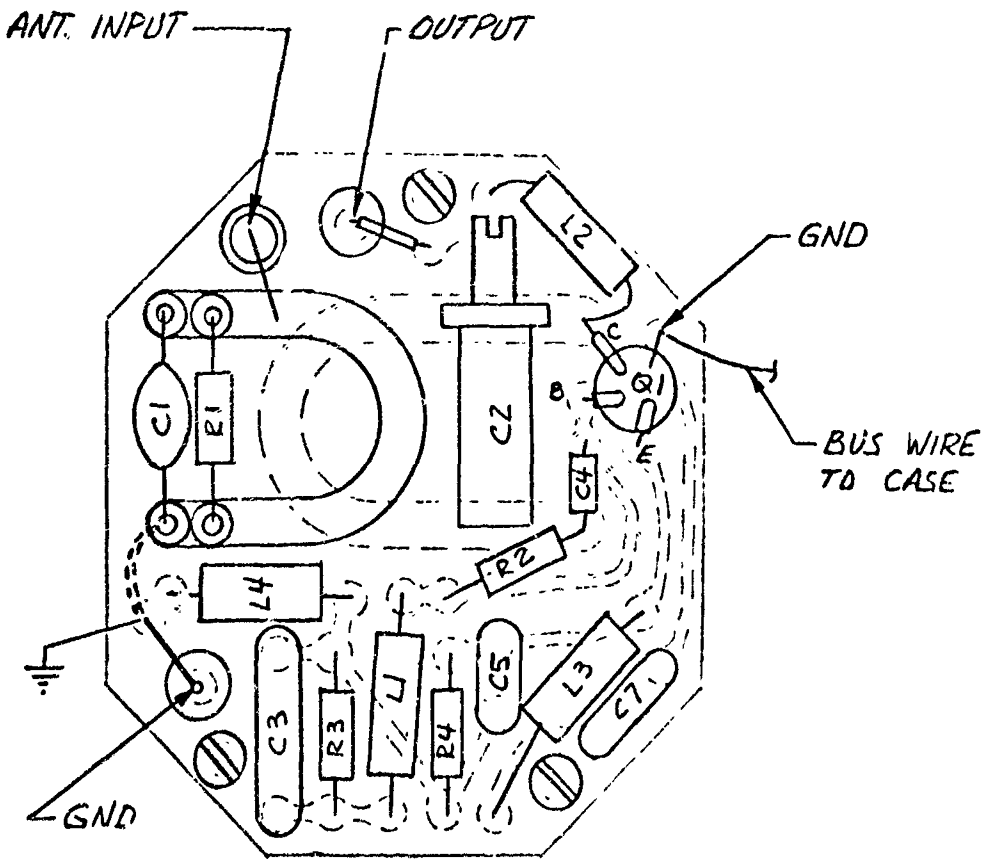
| REV. | A | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|




C20
C23 } SELECT AT TEST
R32

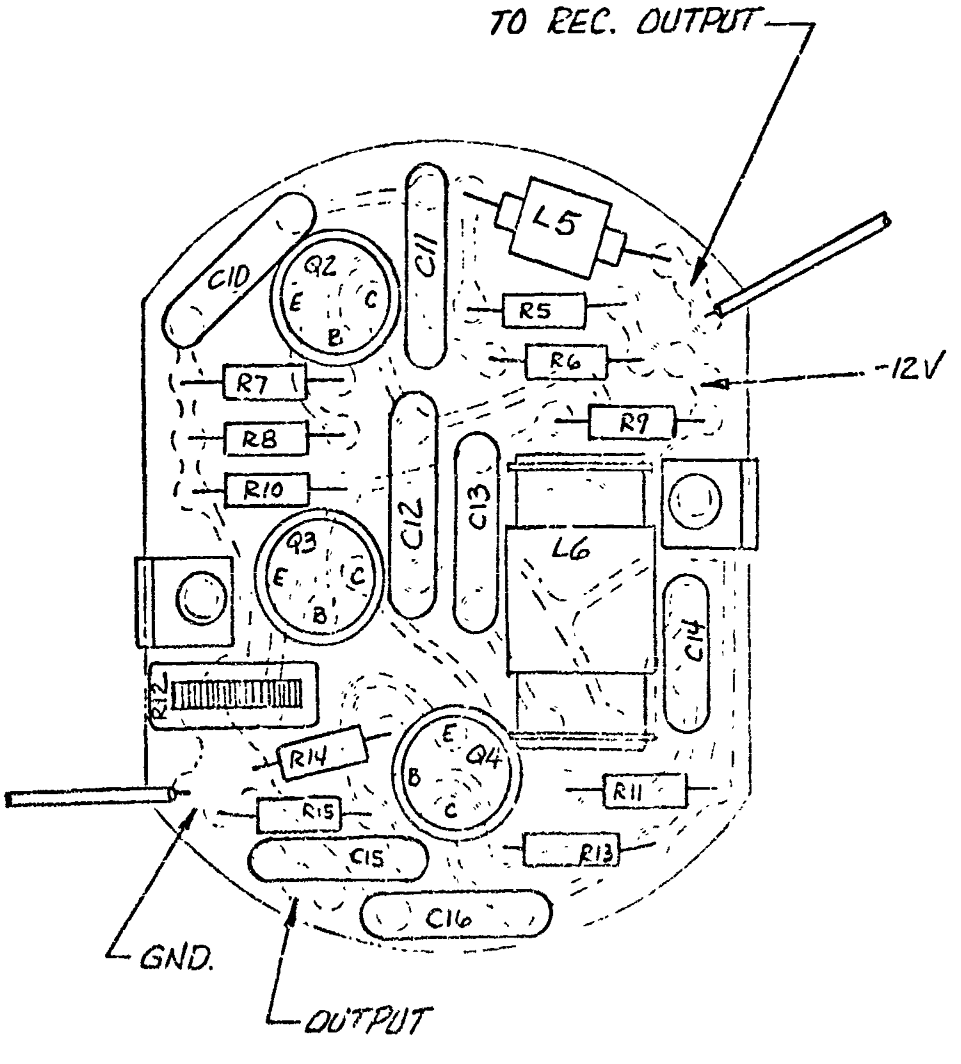
MODULE "D"
MET PULSE GENERATOR
2410777

| REV. | A |
|---|---|




MODULE "E"
RECEIVER ASSY
2410781

| REV. | A | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|




MODULE "F"
82 KHZ AMPLIFIER
2410776

Unclassified
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13. ABSTRACT


The results of a program to develop, design and fabricate a low-level telemetry subsystem to operate in the lower 1,000 meters of the atmosphere and compatibly interface with a modified Rawin Set AN/GMD-4 is presented herein. The subsystem has been designed to provide a detailed analysis of the temperature, humidity and wind structure of the lower atmosphere, employing standard radiosonde sensors and transponder techniques, and consideration has been given for the use of modular construction to facilitate updating as new techniques and equipments are developed. The telemetry device is adaptable for use as a balloonsonde designed for data acquisition on ascent, or as a rocketsonde providing data acquisition on descent, upon deployment of a parachute and a sensor mounting package.

Utilized in the design of this telemetry device are: a solid state and integrated circuit commutator, with a sampling rate of one cycle per second, and a solid state microwave transmitter. The relatively high sampling rate of one every second provides a more complete synopsis of the atmospheric construction than have previous balloon borne or rocket sounding telemetry devices.




DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE

Unclassified
Security Classification

| 14 KEY WORDS | LINK A | | LINK B | | LINK C | |
|---|---|---|---|---|---|---|
| | ROLE | WT | ROLE | WT | ROLE | WT |
| Rocketsonde | | | | | | |
| Balloonsonde | | | | | | |
| ML 419 Temperature ensor | | | | | | |
| ML 476 Humidity Sensor | | | | | | |
| AN/GMD-4 Data Processor | | | | | | |
| Teledynamics Meteorological Data Processor | | | | | | |
| Sonex Meteorological Data Processor | | | | | | |
| Cricket Rocket | | | | | | |
| Radiosonde | | | | | | |
| Low Level Sonde | | | | | | |